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Determining and Testing Factors Impacting Upon the Supply of Minority and Women Scientists, Engineers, and Technologists for Defense Industries and Installations

Phase I Final Report

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for

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This research note addresses projected U.S. demographic trends, which forcast a continuing shrinkage of the 18 to 24 year old population, and a continuing increase of the percentage of minorities in the total population. This poses a problem not simply for military recruitment, but for the ensuring of a sufficient supply of scientists, engineers, and technologists (SETs) for the U.S. defense industry.

This research note's preparation included an intensive and extensive

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literature search, and the prioritization of the references into categories. This was followed by conducting interviews to validate the factors which the literature search showed to be influential.

Phase I of the project has produced a computerized database of 682 references related to the subject of women and minorities in SET studies and careers (including mathematics and computer science) and to the determination of the factors which previous researchers have found to affect the decisions of women and minority members to pursue SET careers. In addition, successful intervention programs have been targeted for some populations.

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FOREWORD

Increasing the number of minorities and women in quantitative careers is one solution to the potential shortage of personnel in these areas. The underrepresentation of minorities and women in science, engineering, and technology has increased the need for detailed information about their career motivations, decisions, and aspirations. Although access is no longer a problem as in previous years, these groups do not pursue careers in science and engineering at rates proportionate to their numbers in the American work force.

This report examines the problems encountered by minorities and women as they seek to engage in nontraditional careers in engineering, physics, chemistry, physics, computer science, environmental science, and mathematics. Through an intensive literature search, the study identifies research gaps and proposes a longitudinal prototype study plan designed to gather missing data.

EXECUTIVE SUMMARY

Requirements:

The requirements of the study are twofold:

To identify the variables which researchers have studied in their investigations of the underrepresentation of minorities and women in quantitatively based study and careers; to determine research gaps; to identify intervention strategies utilized to increase participation by women, American Indians, Blacks, and Hispanics; and to develop a longitudinal prototype plan to test the most promising of the strategies.

To provide a knowledge base to improve recruitment and retention strategies of minorities and women for DOD civilian personnel, ROTC science/engineering programs, and uniformed Active, Reserve, and National Guard professionals and to consider new ways defense contractors may help to increase the pool of American scientists, engineers, and technologists (SETs).

Procedure:

In this multiphase Study, Phase I's primary task was to build upon already accomplished research by aggregating it in a computerized data base usable as a research tool. The approach utilized a literature search to delineate a body of research documents relating to minorities and women, quantitatively based careers, and educational levels of ninth grade through PhD.

Interviews were held with incumbent SETs and students studying these subjects to give external validity to the findings of the literature search. Key and seminal documents were sought from experienced and nationally recognized researchers in this area, to provide internal validity to the data base. The analysis of prior research revealed gaps, and these have provided a basis for the design, development, and proposed testing of interventions to be used in a prototype longitudinal study plan (PLSP).

Findings:

Consensus is that a potential shortage of American scientific and technical personnel exists, beginning around 1995, and even earlier, in some occupational categories such as electrical and electronic engineering. These shortages would be exacerbated under emergency mobilization conditions. Additionally, there is consensus that the reasons for the disproportionate representation of minorities and women in these occupations are poorly understood. The major research gap is in data using sex and race/ethnicity as linked variables; for example, American Indian males, Black females, and Hispanic females.

Although it has been known for some time that Asian Americans are "overrepresented" in engineering, the natural sciences, and technical occupations, the causes have been relatively obscure. Most of the recent data cite cultural causes including values, family pressure, and lack of linguistic expertise in English. However, these assumed causes have not been operationalized or tested.

Outcomes include determination of the factors which previous empirical research has measured and found to have an impact on the decisions of women and minorities to enter quantitative fields and to persist in those areas of study and careers. In addition, successful intervention programs have been targeted for some subgroups, primarily the National Action Council for Minorities in Engineering (NACME) programs. A research design was developed (the Prototype Longitudinal Study Plan) to test promising and innovative intervention strategies.

Lack of theory also hampers the efforts to find a treatable cause for the lack of interest, aptitude, motivation, or ability--or perhaps all four--of minorities and women to pursue a quantitative or technical career.

Utilization:

One of the challenges to our government, industry, and academia is to achieve proportional representation of minorities and women in all sectors of the work force--including those dealing with engineering, science, and technology. In spite of all the efforts and expenditures since the Soviet launch of Sputnik in 1957, the Civil Rights Movement of the 1960s, the Women's Movement of the 1970s, and the numerous programs funded by the Federal Government, the numbers are still far below parity, suggesting that solutions are yet to be found.

Through lack of representation, these segments of the American population are excluded from the mainstream of U.S. society, which is increasingly technologically driven. Not only is occupational segregation the result, but also the more critical issue of the loss to the creative and innovative human resource base of American productivity--and thus ultimately our entire Nation. The findings of this longitudinal study will offer alternatives, interventions, and strategies which if properly applied will result in the enhanced recruitment and retention of American Indians, Blacks, Hispanics, and women in scientific, engineering, physical, computer and environmental science, and mathematical study and careers.

The slow growth of these groups in selecting careers in SET fields has increased the need for detailed information about barriers, career decision-making, selection, and persistence. Application of these findings can give the DOD new directions in human resource efforts to increase the pool of qualified professionals available for uniformed and civilian employment in defense industries and installations.

This report proposes a longitudinal study approach to this defense preparedness issue with the lead taken by a consortium of predominantly minority higher-education institutions evaluating and testing interventions designed to improve recruitment, selection, performance, and retention of minorities and women in these studies and careers.

A STUDY TO DETERMINE AND TEST FACTORS IMPACTING UPON THE SUPPLY OF MINORITY AND WOMEN SCIENTISTS, ENGINEERS AND TECHNOLOGISTS (SETS) FOR DEFENSE INDUSTRIES AND INSTALLATIONS PHASE I FINAL REPORT

INTRODUCTION

This final report of Contract MDA903-85-C-0342 covers the work performed in Phase I of a projected 5-year longitudinal study conducted by the Center for the Advancement of Science, Engineering, and Technology (CASET), at Huston-Tillotson College, from September 2, 1985, through October 31, 1986.

In the report, CASET addresses problems and solutions surrounding the issue of the underrepresentation of American Indians, Blacks, Hispanics, and women in science, engineering, and technology (SET).

Because of the historic and contemporary disproportionate representation of certain minority groups and women in SET occupations, these have come to be labeled "nontraditional" fields for these populations. Culture defines what is "man's work" and what is "woman's work." Thus, certain jobs are considered "masculine" and others "feminine." Occupational stereotyping is as prevalent as sexual, racial, and/or ethnic stereotyping. The combination of dual stereotyping can be a powerful barrier for minorities and women.

The background to the study follows this introduction. This section gives the research questions and discusses the research approach for Phase I.

After the discussion of the study's background, the report presents an overview of the findings from the literature search and the CASET data base, from interviews with minority and women SET incumbents, from an interview with a Black student (presented in more detail in Appendix A), and from a group interview with defense industry personnel administrators. The final portion of this section is the proposal for a 3-year Completion Phase; it includes the design and test plan for modular interventions derived from the most promising approaches found through the literature search.

The overview is followed by a discussion of Phase I findings. The final section contains the conclusions of the

Principal Investigator (PI) and the Co-Investigator and gives recommendations for future action policy options.

BACKGROUND

The study arose out of the concern by Dr. John Q. Taylor King, Major-General, AUS-Ret. and President of Huston-Tillotson College, Austin, Texas, that more minorities and women were not filling professional scientific and technical positions among uniformed and civilian Department of Defense (DOD) personnel.

For some years between 1978 and 1981, Dr. King discussed the problem with fellow officers and government officials. Deciding to take action, in 1981 he asked the CASET Study Co-Investigators, Dr. Nina W. Kay and Professor John W. Wiersma, to cooperate with him in writing an unsolicited proposal for submission to Secretary of Defense Caspar W. Weinberger. On August 19, 1982, a proposal was formally presented at the Pentagon to Secretary Weinberger, who appointed a task force to ascertain that the scope was within the DOD mission. The proposal was subsequently modified; and on September 2, 1985, a contract was awarded to CASET at Huston-Tillotson College for "A Study to Determine and Test Factors Impacting on the Supply of Minority and Women Scientists, Engineers, and Technologists for Defense Industries and Installations." The Center for the Advancement of Science, Engineering, and Technology was established by the Board of Trustees of Huston-Tillotson College to carry out this study and for the development and strengthening of mathematics and science programs at the College. The Army Research Institute for the Behavioral and Social Sciences provided technical oversight.

Demographic Trends

A need for qualified American National scientists, engineers, and technologists (SETs) continues to be a problem in the United States, affecting the ability of both the DOD and defense-related industries to accomplish their missions. The National Science Foundation (NSF), along with other Federal and private sector organizations, projects that the rapidly improving economy will exacerbate the shortage of American SETs unless action is taken to increase the supply.

According to the 1980 census, there were 238 million Americans. Anglos comprised 83.15%, Blacks 11.69%, Hispanics 6.4%, Asian 1.5%, and American Indians 0.6%. However, fertility rates and immigration are expected to change that picture by the year 2020.

Between 1950 and 1980, the U.S. population as a whole grew by about 50%. However, the Hispanic population increased by

265%. Hispanic birthrates did not decline in the past two decades as they did for Anglos and Blacks. Blacks still continue to have more children (2.4 per female) than Anglos (1.7 children per female), while 2.1 represents zero population growth. Asian Americans also have a great growth potential as they are 44% of the nation's recent immigrants. By 2020, Hispanics are expected to be the nation's largest minority group, totaling about 14% to 17% of the U.S. population, while Blacks will constitute about 14% to 16%, Asian Americans approximately 5%, and American Indians about 1%. In other words, by the year 2020, over one-third of the nation will belong to a minority group.

Also changing are the demographics of college populations. Although over half of the total number of America's high school graduates go on to attend a college or university, the percentage is less for minority groups. For example, the proportion of Blacks continuing on to college has declined from 48% in 1975 to 38% in 1983. Yet by 1995, Blacks and Hispanics will constitute almost 40% of America's college-aged cohort.

Decline in numbers of 18- to 24-year olds. Demographic trends indicate a 22% decline in 18- to 24-year olds by 1995, significantly reducing the college-age Anglo male population which traditionally has supplied the largest numbers of SETs to DOD and defense installations. In absolute numbers, the drop will be from 30 million in 1982 to 24 million in 1995. Significant changes have occurred in population growth since births began to decrease in the early 1960s and to drop consistently during the subsequent 15-year period.

Approximately all of the post-World War II baby-boom generation have now reached working age, and for the remainder of this century America will experience a steady decline in the number of young persons entering the job market. As the number of high school and college graduates declines, the national shortage of SETs may rise proportionately.

Increases in minority populations. Additionally, more of the United States population will belong to minority groups. Some forecasters predict that by 2050, Asian Americans will comprise 6.4% of the U.S. population. Another forecast is that by 2040, Hispanics will be the largest minority group and that Anglos will actually be a numeric minority.

The Ford Foundation, in a 1984 report on demographics, reported that the percentage of minorities 18 years of age and younger had risen from 15% in 1950 to 36% in the 1980s. In 1980, 31% of Blacks were between the ages of 5 and 19; they comprised approximately 16% of the public elementary and secondary school enrollment. With the higher fertility rate of Hispanics and the youthfulness of this group (the average age is 22 compared to 31 years old for Anglos), their numbers in elementary and secondary

schools are also increasing. Harold L. Hodgkinson, Scholar in Residence at the American Council on Education (ACE), reported that half the states have public schools with a 25% or more non-Anglo enrollment: California has a "majority of minorities" in elementary schools, Texas schools are nearly 50% minority, and the 25 largest city school systems also have a greater than 50% minority enrollment (1985).

Hodgkinson (1983) has estimated that the percentage of primary and high school minority students will grow to 33% by 1990 and to 38% by the year 2000. The figure nationally now stands at 30%. When one considers the low percentage of minority students who continue in school after the ninth grade, it is clear that if these students went on to graduate from high school, the percentage of minority students would be even larger.

Education in the United States is facing a paradoxical situation with regard to minority students. At a time when the percentage of the American population which is minority is increasing, the numbers of minority teachers appears to be decreasing. The reasons for the decline in minority teachers are varied, but the fact is that the attrition has been going on for some years. It surely is related to the percentage of undergraduates in minority groups receiving bachelor's degrees in education.

Statistics from the Department of Education's (ED) Office of Civil Rights showed that the percentage of minority bachelor's degrees in education declined by 52% between 1976 and 1983 (from 14,209 to 6,792). The decline for Anglos during the same period was only 40% (from 135,464 to 81,650). The reduction in minority teachers is a result also of the decline since 1976 of minority enrollment as a percentage of all students in four-year colleges and universities. Part of this decline is a function of the increasing dropout rate among minority high school students as well as the steady decline in the college-going rate for Black high school graduates. Rising college costs and decreasing Federal assistance have affected minority students disproportionately.

There are no recent statistics to document how many of the nation's 2.5 million primary and secondary teachers are minority. The Federal Government has not collected data on this subject for 5 years. However, a 1980 ED report cited 12.5% of the teaching force as being from minority groups. Blacks represented 8.6%, Hispanics 1.8%, and other groups the balance. The data suggest that in states with high minority populations, the percentage of teachers may not come close to the percentage of minority students in the classroom. Educators point out that the lack of minority teachers to serve as role models can have an adverse effect on minority students in forming their own identity and career goals.

Increase in foreign national SETs. Foreign nationals constitute a large percentage of the students now engaged in scientific study, particularly at the graduate engineering level. In 1985, 1,400 out of the 3,383 engineering PhD's awarded went to foreign nationals who cannot obtain U.S. security clearances and are not available for direct DOD employment. This situation further reduces the effective supply of qualified SETs available for defense-related employment.

Erosion of Worldwide Technological Leadership

The Soviet Union graduates more than twice as many scientists and engineers as the United States and almost five times as many engineering students. The United States ranks third behind the U.S.S.R. and Japan in a comparison of the total number of engineering graduates and in the number of engineering graduates relative to the size of the population.

Not only do we look forward to a shortage of U.S. science, engineering, and technology employees but also to the the fact that the current work force is an aging one. A study of engineering personnel conducted by the Joint Logistics Commanders, Department of Defense, found that 19% of all American engineers would be eligible for retirement by 1995. Additionally, the Report stated that in Army laboratories, 38% of the 507 science and engineering personnel leaving within a recent 18-month period did so in order to retire.

State of Quantitative Education in the United States

Since the early 1980s alarm has been expressed concerning the state of American education vis-a-vis science, mathematics, and technical subjects. In April 1982, at Senate hearings for the National Science Foundation (NSF) funding authorization, F. James Rutherford, Chief Education Officer of the American Association for the Advancement of Science (AAAS) stated that science, mathematics, and engineering education in America were in rapid decline, resulting in a progressive undermining of U.S. economic health, productivity, and national security.

Yet again in 1985 at the AAAS annual meeting, lack of scientific and technological literacy was still being deplored and documented as a major problem of American society. The same condition prevails today that did in 1982 when growing SET illiteracy was addressed at a conference organized by the Office of Science and Technology Education to establish the "Coalition of Affiliates for Science and Mathematics Education."

Some researchers place a level as low as 10% of the population who could be considered scientifically literate. In

December 1985, the American Association for the Advancement of Science held discussions on the topic of scientific literacy and, in fact, how to define it. John Miller of Northern Illinois University has conducted extensive polls on the subject and believes that literacy in science should include a knowledge of the process of science, and ability to understand some of the terminology of science and an awareness of science's social effect.

In 1975, the University of Texas found that one in five adults could not read well enough to perform simple tasks, such as reading a job notice or a child's report card. Based on the Texas study, the Department of Education (1986) estimated that 23 million adults were functionally illiterate and 35 million more were semi-illiterate.

An ED report released September 24, 1986, found that 5% of America's young adults are illiterate and 20% are semi-illiterate. The report, "The Young Adult Literacy Assessment," surveyed 3,600 people and is the latest in a series of studies on literacy. In the spring of 1986, another ED study, based on the survey of 3,400 adults who were 20 and older, estimated that 17-21 million adults, or 13% of the population, were illiterate.

APPROACH

The plan of work for Phase I focused on an intensive literature search, selected field research, and development of a prototype longitudinal study plan (PLSP) for testing variables found to be influential in scientific, engineering, and technological study and careers for minorities and women. Since this study was intended to suggest polity options, the initial step was the development of research questions, which would provide a structure for framing the issues.

Research Questions

1. What factors have led to the underrepresentation of minorities and women in SET college majors and SET careers?
   - 1.1 Can economic, institutional, and cultural factors be identified?
     - 1.1.1 Are the factors similar for recruitment into college majors and careers?
     - 1.1.2 Are the factors similar for retention once college majors and careers have been chosen?

1.2 Can factors associated with the individual be identified?

1.2.1 How might minorities and women who choose SET majors and careers differ from those who do not?

1.2.2 How might minorities and women who remain in SET majors and careers differ from those who leave?

2. What techniques have been used to recruit and retain minorities and women into SET college majors and SET careers?

2.1 Which techniques have proved effective and which have not?

2.1.1 What forms of program evaluation have been used?

2.1.2 How has "effectiveness" been defined?

Research Methods

Phase I focused on data base compilation and literature searches in order to produce the computerized CASET data base deliverable. The initial step was to assemble a master list of all possible sources of documents dealing with the reasons--empirical, historical, anecdotal, and conjectural--that women and certain minority groups do not participate in the physical sciences, engineering, environmental sciences, computer sciences, mathematics, and other technical fields at the same rate as Anglo males. A corollary purpose was to investigate the overrepresentation of Asian Americans in these fields.

A list was compiled of some 2,400 journals covering the subjects of investigation (see Appendix B). Other resources were potential consultants and known experts, foundations, Federal agencies, industries, and other organizations that might have data, and universities and colleges with engineering programs. The vast number of journals indicated that a multidisciplinary computer search of extant data files would be cost-effective (see Appendix C for list of data files searched). Some 39 key files were searched several times. In each instance, the beginning variable was a particular subgroup. Because of the complexity of the study, one search per data file was not feasible. Manual searches of key journals would be conducted later in the literature search.

The range of the literature search was ninth grade through PhD and the minority groups of American Indians, Asian Americans, Blacks, Hispanics, and women. Topics were the physical sciences, engineering, mathematics, computer sciences, biotechnology, and environmental sciences.

The literature search used three methods: 1) searches of computerized data files in data bases such as the Educational Resource Information Center (EPIC), the National Technical Information Service (NTIS), the Defense Technical Information Center (DTIC), and University Microfilm International (UMI); 2) manual searches of 1980-1986 issues of those journals found to have contained numerous and/or particularly relevant references such as Chemical and Engineering News, Engineering Education, Journal of Research in Science Teaching, U.S. Black Engineer, and Science, and to locate documents obtained through inclusion in other researchers bibliographies; and 3) referrals by Advisory Group members, consultants, conference, workshop, and seminar participants, and other interested persons.

The data file search utilized multiple strategies of ranking the descriptors hierarchically in various combinations and testing to see which turned up the most literature. For example, a strategy using American Indian (Native American, North American Indian) as the primary descriptor and working down through careers (and related), high education (and related), found more items in PSYCINFO data base and in ERIC than did the reverse strategy; i.e., starting with careers (and related), going down to science, engineering, and technology (and related), and then to minorities (and related) and women.

The magnitude of the documents called for rigorous prioritizing for relevance. Empirical studies were the highest priority with seminal works and comprehensive summary documents following. The documents were first categorized (see Appendix D for criteria), then prioritized, and selectively entered into the CASET data base. Phase II would include the continued building of the CASET data base from these documents.

Coding sheet. A coding sheet (see Appendix E) was designed so that the data in the documents could be analyzed. Additionally, an analysis would be conducted of the documents themselves, aggregating them in ways which reflected the research that had been carried out in this area of female and minority SETs. The documents concerned these subgroups in a variety of ways which broke out into the following categories:

- o educational
- o career
- o personal
- o cultural
- o economic

CASET data base procedures. The following procedures were followed:

- o Search strategy determined

- Literature search conducted
  - Computerized data file
  - Manual
  - Referral
  - Telephone
- Abstract obtained (off-line printout or other)
- Documents categorized into six groups according to criteria termed A, B, C, D, E, and F. Only A's were eligible for inclusion in the computerized data base.
- Hard copies of documents obtained
  - Sources such as government agencies and departments, NTIS, ERIC, UMI
  - Journals in libraries
  - Letters and/or phone calls to researchers, foundations, legislators, professors
- "A" documents coded to provide information on five groups of factors: cultural, career, personal, economic, and educational. This methodology was designed to break references into discrete units that could be summed.
  - The populations were already broken into 10 discrete units; female and male groups of American Indians, Anglos, Asian Americans, Blacks and Hispanics.
  - Using the populations and the factors, or any subset thereof, allowed for ease of creating matrices or cells that could graphically display both what the literature search revealed and also gaps in the literature or research described in the literature.
  - This design was intended to break up minority populations researched in documents as completely as possible because the present system of research that "lumps" groups into "women" and "men" or "minority" obscures the questions which the researchers are asking, making the answers less than relevant and useful.
  - After a preliminary drafting of the coding sheet, it was tested.

- After testing, the coding sheet was sent to Consultant Harris Cooper, PhD, for review.

- o After review by Dr. Cooper, the coding sheet was tested again. This cycle was repeated three times before deciding upon the final version of the coding sheet and proceeding with the bulk of the coding.

- o CASET documents entered into data base

Interviews. As external validation of the findings from the secondary sources, interviews were conducted with SET students, SET incumbents, and industry administrators.

INTERVIEWS

Interviews were included as a part of the methodology for the study in order to ascertain the external validity of the findings of the literature search. The subjects were selected on an opportunistic basis rather than by random selection. The methodology was exploratory in nature; the plan was to analyze the content on the entire interview at a later date through the use of ZyINDEX Software. ZyINDEX is a full-text search and retrieval software that has been used in court trials such as the General Westmoreland versus CBS case. However, the search capability works equally well for interviews. The field capability allows for limited searches for a word or phrase within a restricted area of a document. The software also has a search capability for proximity between words (i.e., words within five words of each other). ZyINDEX also has synonym capability, increasing the scope of the search by choosing more than one synonym. At this time, however, we do not have the capability of entering the entire interview on the computer. Thus, the analysis is much more limited.

Interview techniques included one-on-one, focus groups, and one-on-one with a participant observer. All interviews were conducted in Texas. While it is dangerous to extrapolate to larger populations from interview and focus group data, the results can be used to generate hypotheses to be tested at a later date with a probability sample. Interviews will be carried on in Phase II and in the Completion Phase in order that results from all interviews may be utilized in building models and developing hypotheses. In the meantime, qualitative data from sources such as interviews give context, background, and enlightenment to quantitative data from surveys and demographic statistics. Interview questions are frequently "open-ended" in order to encourage the interviewees to speak at length and in depth about their feelings, motivations, attitudes, and perceptions. The findings may change the assumptions of the

interviewer and cause modifications in the unstructured interview itself.

The importance of interviews cannot be overstated. In human research, there is no substitute for the interview. The basis of the informant-interviewer relationship is rapport, which can only be established on a face-to-face basis. Another basis of the interviewee-researcher relationship is trust and understanding. This cannot be developed without a face-to-face interview; and without its development, the desired results cannot be achieved.

The atmosphere of the interviews was informal, and the aim was to create an ambience wherein the interviewees could express themselves on a variety of themes which the literature search had indicated were related to SET career choice.

The results of the interviews suggest that a rich ethnological vein of data is not revealed by questionnaires or survey instruments. Although the topics may be the same in some instances, the unstructured interview allows for depth of data collection that touches on qualitative aspects of career choice and persistence such as self-image, self-concept, self-identity, family expectations, quality of life at academic institutions, and responses to the tenseness of the unfamiliar and nontraditional atmosphere in which the female or minority student or incumbent all too often find themselves.

The results of these interviews also point to the utility of collecting qualitative data as a background, context, and framework against which to place quantitative data. The DOD needs to know the cultural factors that affect minorities' and women's career decision-making. These interviews suggest that case studies may be the most effective means of getting at these factors and may justify the use of computerized content analysis as a methodology to quantify interview data.

The approach used in the interviews was a life-cycle approach, beginning with early education and moving up through post-secondary education and using the context of the educational experience to spark memories and experiences and recall events. In the life-cycle approach, the interviewer looks for patterns and cultural themes and focuses on cross-cultural communication as a basis for understanding the experiences of members of different racial and ethnic minorities.

The number of individual interviews conducted was disappointing; the PI encountered scheduling difficulties which will be remedied in later phases of the study.

Other interview data and anecdotal reports reinforce the case study findings on group and individual interviews. For example, at the University of California at Berkeley, only 142

Blacks graduated in 1986; and of 1,536 faculty members, only 34 are Black. The lack of minority students and faculty give minority students a feeling of isolation and alienation, as one interviewee candidly discussed (see Appendix A), and creates that "chilly" classroom climate described by Hall and Sandler (1982).

Focus Group Interviews with SET Incumbents

In two focus groups, the life histories of 12 individuals from a population of women and ethnic minority engineers and computer scientists were gathered. All were employed by Defense-related contractors in Texas. The ages of the sample population ranged from 24 to 37. All individuals in the sample were by definition successful; i.e., employed in science and engineering fields. All of the respondents in the sample were born into blue collar families except for three females and one male. The gender/ethnic breakdown of the 12 individuals is as follows:

Black Males	5
Black Females	2
Hispanic Males	1
Hispanic Females	1
Asian Females	2
Anglo Females	1

In obtaining life histories, the researcher asks an informant to recreate and recount his or her life. This, however, is more difficult than at first it might appear. The researcher must allow informants the opportunity to examine carefully the major events of their lives and at the same time provide direction to the informant without adding too much structure to the story. The accuracy of an informant's memory of specific events such as their salary in 1976 or the "fairness" of their supervisor is relatively unimportant. The significant informant in the life history is the cultural context in which the respondents place the events of their lives. Life histories are valuable aids because they are often a means of obtaining information about a person's concept of self and perceptions of his or her social and work universe. Data from life histories are important because they complement more traditional structured and quantifiable methods. Collecting life histories is tedious and time demanding, but there is little doubt that this is methodological approach is important (see Langness, 1965; Langness & Frank, 1981; Pelto & Pelto, 1970).

Analysis of the content of the life histories may be summarized as follows:

1. Females tend to be younger than their siblings and come from smaller families than males. In only two cases,

however, are the respondents from families with more than four children.

2. The marital stability of the parents of the respondents conforms to the national averages--50% of the respondents' parents are divorced.

3. Females describe their preschool life as a period in which they usually played alone and spent a great deal of time daydreaming.

4. Males describe their preschool life as a period in which they played with their friends. They perceive themselves to have been typical little boys.

5. Female respondents all said that they had an interest in and demonstrated mathematical skills during grade school.

6. Males said that they did not develop an interest or skills in science and mathematics until they entered junior high school.

7. Both males and females said their worst subject area in grade school was English.

8. Males considered themselves to be active and playful children with many friends during grade school.

9. Females said that they perceived themselves to be a little different--more of a loner--than most girls in grade school.

10. During the junior high school period, both male and female respondents had recognized that they were interested in science and math or at least that science and math was relatively easy for them.

11. During the junior high years, the females were not actively involved in extracurricular activities. Instead, they devoted their time to their studies.

12. Most of the males were either involved in sports or science-type extracurricular activities during junior high school.

13. Neither males or females were interested in dating during junior high school.

14. All of the respondents had been encouraged and praised by at least one science/math teacher by the time they were ready to enter high school.

15. By the time the respondents entered high school, most of them had developed a strong interest in science and math.

16. All of the males held part-time jobs during high school (mostly in the fast-food industry).

17. Only one female respondent held part-time jobs during high school.

18. Both females and males were involved in science-type extracurricular activities during high school.

19. Both males and females had their first date during high school, although neither were actively involved in dating activities.

20. Most of the females said that they believed they were perceived by most other students in high school as "bookworms."

21. Most of the males said that they believed they were perceived by most other students in high school as "nerds."

22. All of the respondents were able to maintain a 3.0 average in high school despite the fact that they had trouble in subjects such as English and the social sciences.

23. Most of the respondents attended universities located not far from their homes.

24. Females tended to attend college on some form of academic scholarship, whereas males tended to attend college on some form of government-supported loan/scholarship.

25. All of the respondents graduated from college with at least a 3.0 average and in the top 25% of their major.

26. All of the respondents had developed a positive attitude about college and for many years assumed that they would obtain an education beyond high school long before they entered a college.

27. Most of the respondents enjoyed the academics of college but perceived themselves to be somewhat of a "loner" and not very socially active.

28. Most of the respondents have attained a higher level of economic and professional success than their siblings.

29. The respondents noted that their gender and/or minority status was a mixed professional blessing; it could be both a stimulus and a deterrent to professional advancement.

30. The respondents were unable to articulate why they had attained a relatively high level of professional success.

From these specific patterns of behavior, it is possible to abstract the following basic themes reflecting the behavior and self-perception of successful women and minority engineers.

1. Male minority and female engineers share numerous life experiences, but they also have many life experiences that they do not share.

2. Male minority and female engineers demonstrate an interest and above-average capability in the math/science field as early as grade school.

3. By adolescence, male minority and female engineers have generally committed themselves to the science/math field and have been defined by most of their peers as "loners" or "nonsocial."

Interview with a Black Female Electrical Engineering Graduate Student

The PI conducted an unstructured 2-hour interview of a Black female pursuing a PhD degree in Electrical Engineering at a Texas public university. The subject, Kim (a pseudonym), had a B.S. in Electrical Engineering from a historically Black state institution.

The life cycle approach of the interview yielded the following data about the interviewee (see Appendix A for the complete text of the interview):

1. Kim came from a small family; her role model was her father, who was a high school mathematics teacher.

2. Kim had received encouragement and advice by a high school counselor; the counselor's advice led to her studying engineering rather than mathematics.

3. Kim attended college on some form of scholarship.

4. She felt that she had not expected the difference between the two universities and that her present quality of life rated "low."

5. Kim noted that her self-confidence had deteriorated in graduate school.

6. Kim felt alienated from her classmates.

Focus Group Interview With Personnel Staff of a Defense Contractor

The PI interviewed two men and one woman employed in administrative positions in the Personnel Office of a defense contractor in Texas. The hierarchy of the three employees was one man at the top, one man in the middle, and the woman at the lowest ranking position in the office. The purpose of the interview was to discuss the hiring and performance and retention rate of minorities and women in engineering, computer science, and other positions that are quantitatively based, such as mathematician or statistician. The interview was an unstructured interview in an informal setting. Assisting the PI was an Anglo male who had conducted a focus group interview with male minority engineers at the site. Each of the three interviewees brought a different perspective to the interview. In general, they agreed; so their comments will not be identified as to which person made the remark. Rather, the answer presented is a composite of their remarks.

The consensus was that women who do well in engineering are "driven," meaning ambitious, aggressive, assertive. In fact, several males stated in their termination interviews that part of the reason they were leaving was, "I can't work for her." The company had no statistics available on the number of women working, the number of minorities working, and the number of either in supervisory positions. As they pointed out, a lot of supervisors do not show up as such but rather are classified as the senior engineer, although they function as a supervisor. This comes out, then, when someone terminates or tells Personnel that they cannot work with a certain person. The same thing is true for women. Women come in and say, "I can't work for that person." However, as yet they have had no experience of a woman being unable to work for a woman, but definitely they had women who said that they could not work for a certain man. As the female interviewee put it, "We have some men who definitely need their consciousness raised."

The interviewees agreed with Dr. Kay, who said: "So it really is role gender conflict on both sides?" The personnel people saw the women who work as engineers as "they're kind of one of the boys. As a consequence, these women tend to act a little bit like boys, talk a little like boys, and dress a little bit like boys. As perhaps a protective mechanism that was developed in grade school or as they were competing all the way through, the way to be accepted was to effectively become one of the boys." Another interviewee put it that he didn't know whether it was a gender identity crisis, but the female engineers did get their way: "you know, kind of like General Patton did." He went on to say that they got the job done but left bodies in

their wake. He said they see that type of woman engineer "for sure" at their installation. As he put it, "there seems to be some sort of award for being one of the boys." He gave the following example: In one functional area consisting of an all-male group, a white female was hired, whereupn one of the boys said, "Well, this is great, we'll include her in everything we do, just like one of the guys." The interviewee said this is a large group, or about 10 people, like a large club that does everything together; and she was definitely one of the guys. He added that whether or not she felt that way, he didn't know. He had no way of knowing how she felt.

One interviewee pointed out that there were a lot of women getting computer science degrees and math degrees now, and some of their groups were female-dominated in certain areas. However, the female electronics system engineer was still a relatively "lone bird out there." He pointed out that there were more women in the software side than in the hardware side. He felt, therefore, that there was more reason for being one of the boys on the hardware side than on the software side.

In response to the question, " What are you looking for when you hire a minority engineer," the response was "pretty much what we are looking for in general. That's for someone who has probably gone through school with a high grade point average and from a certain type of university, although we do recruit at about five minority-dominated schools. But we're having a tough time out there." It came out in discussion that they felt they were having a hard time recruiting people who fit their criteria and attended minority schools. He did point out that they do hire someone who has the potential, but because of the school they went to, they perhaps did not have experience with the facilities. One example he gave was the difference in the money spent at the two A&M schools in Texas--Texas A&M, which is a majority Anglo institution, and Prairie View A&M, which is a majority Black institution. The feeling of the administrators was that because there are differences in the schools, there are differences in the quality of education. However, they made the point that in recruiting they do look below the surface. They probe for potential that they can work with and bring them "along" in the job. They do have education areas and training areas. In education, the contractor has its college tuition reimbursement program open to all employees to encourage them to get their graduate degrees or continue taking courses relating to their work. Training programs exist to improve skills in their current position--skills that perhaps they could not have gotten in college which are related to the specific environment in which they work and are specific to job requirements. These training programs are available to all employees.

The interviewers asked the administrators to speak about work/study or internship programs with students where they work

part time or during the summer. The administrators came out in favor of those programs saying that although they did not know the statistics are on the persons who have worked for them, they have quite a few people who have been co-op students and have stayed on after graduation and worked. One barrier to the student work/study or co-op program for defense contractors is that the students must have security clearance to be an employee, even on the co-op program. Since security clearances take time and since the students lose the clearance when they quit working, the one semester on and one semester off type of work/study is of little use to the defense contractor. And they do have summer internship programs that are nonprofessional (i.e., clerical), and those, of course, can be performed without security clearance. But on the other hand, they are not career-related internships or co-op programs. And in those jobs, the administrators felt that students would not learn anything that would be of any value in relation to their careers. The one co-op program they had in place was with a predominantly Anglo university. However, they were attempting to start one with Prairie View A&M University.

This particular company was quite active with the Texas chapter of the National Action Council for Minorities, Inc. (NACME), called Texas Association for Minority Engineers (TAME). The company is also active with the city chapter of TAME. The activities related primarily to seventh, eighth, and ninth grade students. They had just started a pilot project in which they were talking to sixth graders and the parents, trying to get the parents interested in seeing that the children took math classes. They also had liaison with the Hispanic engineering organization called SHPE (Society of Hispanic Professional Engineers).

The PI asked about the retention rate of minority engineers. Did these administrators have an explanation for why minorities or, in fact, any engineers, left the company? The response was that of course there is a range of reasons. Some were in an area that was not their particular expertise, some got an offer for a job that was a better career match, and for some of them, it was simply money. As one administrator said, "if you are, say, a good minority woman, you're a hot property, and other people are going to be after you, and buy you. And there's not much you can do when someone offers them some outrageous package. You say, 'Geez,' and just have to wish them luck."

From the standpoint of the industry, most of them are staying within their profession. He added that most of them have jobs when they leave. He could think of one minority female engineer who left this year because her husband was transferred, and she left without having a job. One minority engineer left to change careers and become a minister. In this instance, he changed careers again and reapplied to come back to work. This apparently is not uncommon: employees leave and come back and

are rehired with no prejudice. In fact, if they have their security clearance, it's even better. At the present time, the company had two female engineers who were taking leave for a year to be with their babies during the first year. The feeling of the company was that to come back, they'd have to go through the whole security clearance and reapply for a job, just as if they were starting all over. Plus, "a year of loss of technology is a lot." Such women are really unable to come back at the same level because "we've kept moving and they have stood still."

The administrators indicated that they were interested in interventions that could help with company retain minority engineers and also help them within the company. The company has run some statistics on turnover rates for Anglo personnel and the turnover rates for minority personnel and found out that the minority rate runs higher. Except in 1985, the rates were the same. They felt it was too early to say whether this was a trend or whether it would continue, but they will keep monitoring that. They do not have special programs to help retain minorities, nor do they make a special effort for retention. They mentioned that they are beginning to hear from some of the organizations who speak for minorities in general. Minorities feel that they can get in and get a job, but then they "get stuck" and never rise to the top management positions. So they indicated that they felt the company needed to be studying how fast minorities were moving up. The feeling is that minorities reach a plateau and then stay there, whereas the Anglo males continue to go up. One interviewee said, "I think we're still in the same place we were 8 or 10 years ago" (meaning the same society). He agreed that it could be a subconscious prejudice or as he put it "cultural momentum" in choosing an employee. Where one is a female and one is a male, he felt that his company would probably pick the male because people have a tendency to pick someone like themselves.

One administrator felt that another factor working against minorities and females was that managers were afraid of the repercussions if they found an inadequacy in this person or that person or a problem with job performance: The company would get in trouble with the Personnel Department, or the person might complain to an Equal Opportunity office. The perception from some managers is that they cannot treat minorities and women in the same way they treat the Anglo male. When asked how they perceive Asian Americans, the answer was that "they are a very quiet, hard-working group, and you don't hear a lot from them." None of the personnel staff had ever heard of any objections from Anglo males about working with people of Asian descent.

Another line of questioning developed over stress on the job. They agreed that the jobs were stressful because "a lot of our work is a very fast pace. In other words, they're working on a part of something, they don't know what the whole thing is. And there are incredible amounts of overtime. As in any

contract, it comes down and has to be back out immediately. I guess there's a lot of stress in that." The interviewees did not see any differential in the ways that different members of subgroups (i.e., Anglo males, females, or minorities) responded to the stress. They also pointed out that the security clearance business makes for certain problems, that it is not easy to transfer off a project because there are different clearances for different things. This means a person can't pick up and move over to another project. Additionally, it's hard for management to let people go. They don't want to let someone transfer because they know it may be 8 months before they can get somebody else in here. So in many instances the contractor loses the person to another company, but they do still keep them from transferring departments.

In terms of retention, this company had a single digit attrition rate which it felt was good, and that excluded retirement. They pointed out that companies now did not have employees who stayed with them a long time, as was the case 15 or 20 years ago. They felt that people had a lot of opportunities; and "if we don't promote them quick enough, they'll find someone who will." They feel that the industry is very competitive. One of their recruitment techniques is to get employees to recruit friends. They pointed out that this has been working with the Anglos, male and female, but minorities have not been recruiting their friends in the same numbers. They do not understand why it works better with the Anglos than the minorities.

Part of the perception of the interviewees was that the quality of education today is not the same as it was 20 years ago. One interviewee in particular has the feeling that there is a shortage of what they consider a good engineer according to the criteria of 20 years ago.

The interview closed with some comments from the interviewees on the difference in society in general in education today, with the role model not being there. The example was given that one of the men was at a local high school with one of the engineers, who was talking to the students about staying in school. One kid stood up and said, "My brother dropped out of school in 10th grade, and he's making $50,000 a year". The engineer asked, "What does he do?" The student replied, "He's a pimp!" The interviewee said, "what do you say to that?"

FINDINGS

The result of Phase I research confirmed that much research has been conducted and published on the subject of the underrepresentation of minorities and women in quantitative

fields of physics, chemistry, engineering, mathematics, computer science, environmental sciences, and biotechnology. The documents range in years from 1957 through 1986 and have been found in 140 journals as well as numerous books, papers, conference proceedings, and government reports. The literature search uncovered some 20,000 documents during 202 data file searches. Of these, 9,082 were journal references, 8,203 were dissertations, and another 3,000 were NTIS, DTIC, Ford Foundation, and other reports. Each one of these documents had at least tangential connection with the topics of the literature search; i.e., underrepresented minorities and women, academic levels of ninth grade through PhD, post-secondary vocational training in high-technology fields, and the quantitatively based subjects.

The sheer magnitude of the documents called for rigorous treatment. The documents were categorized, prioritized, and selectively entered into the CASET computerized data base. The literature search is encapsulated in the computerized CASET data base of 682 documents, 370 of which are empirical studies. Empirical studies were a subset of 410 "primary" studies--a more generalized term than empirical referring to studies in which the author interacted with the population, including anecdotal data, case studies, and some evaluation reports. (See Figures 1, 2, and 3 for a breakdown of primary documents by type, research setting, and location and by year of publication and sex of population.)

Overview of Findings

Since the focus of Phase I was a literature search to determine the factors most influential in influencing minorities and women to enter, or not enter, a SET career and to find interventions which were successful, the results were all derived from the literature. Some findings have been confirmed by the interviews carried out with SET students and incumbents. Because Phase II will continue to build the data base and analyze empirical research, the following are considered preliminary findings:

- There is a research gap in the data because sex and race/ethnicity as linked variables are rarely investigated. That is, there are few studies which examine specific subgroups defined by both sex and race/ethnicity; for example, Black females or Hispanic males (See Table 1).
- Minorities and women tend to follow "roadmaps" (Brause, 1987; Tittle, 1986) and "pathways" rather than "pipelines." The data indicate that minorities and women may set career goals later, may stop out more often than Anglo males and Asian

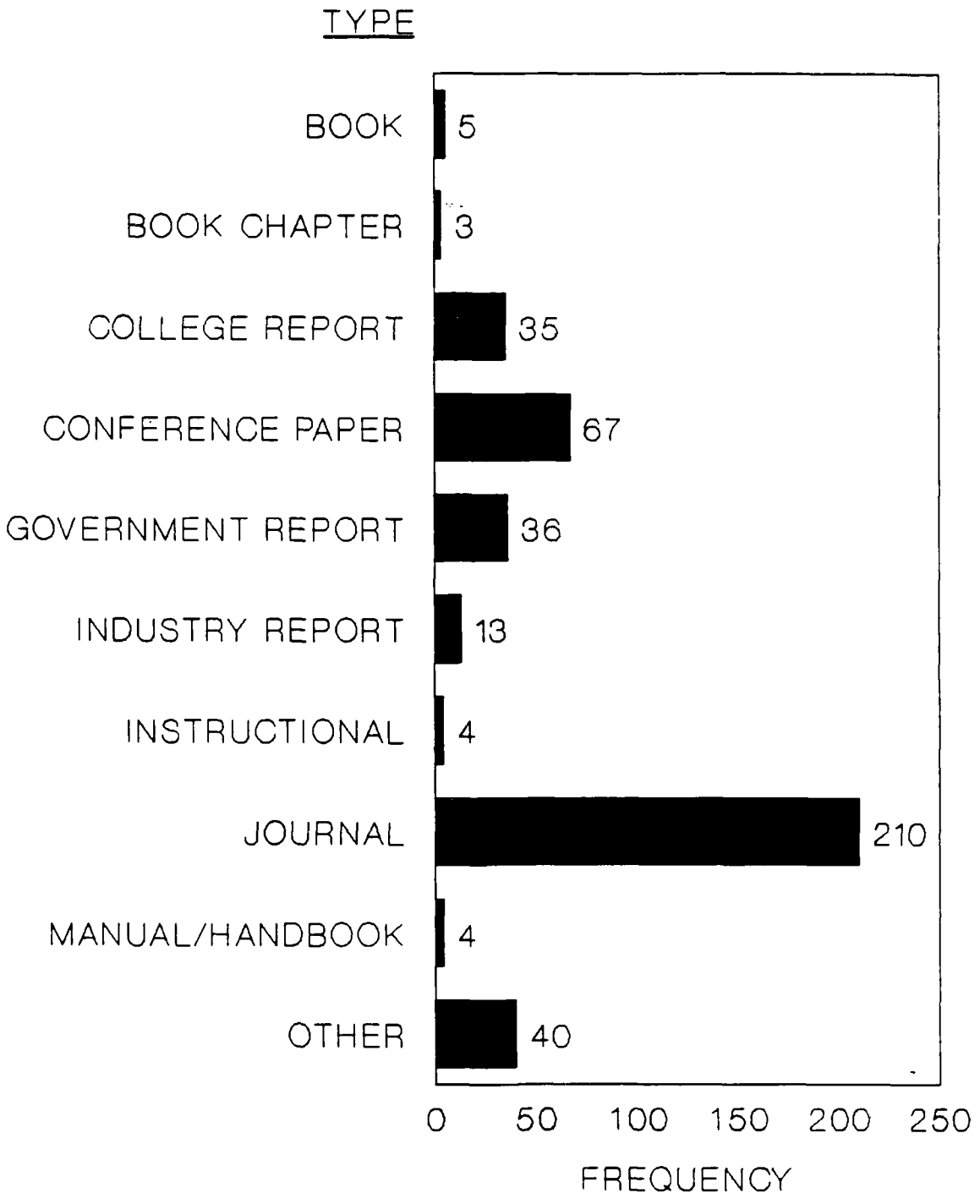

Figure 1. The Distribution of Primary Documents by Type

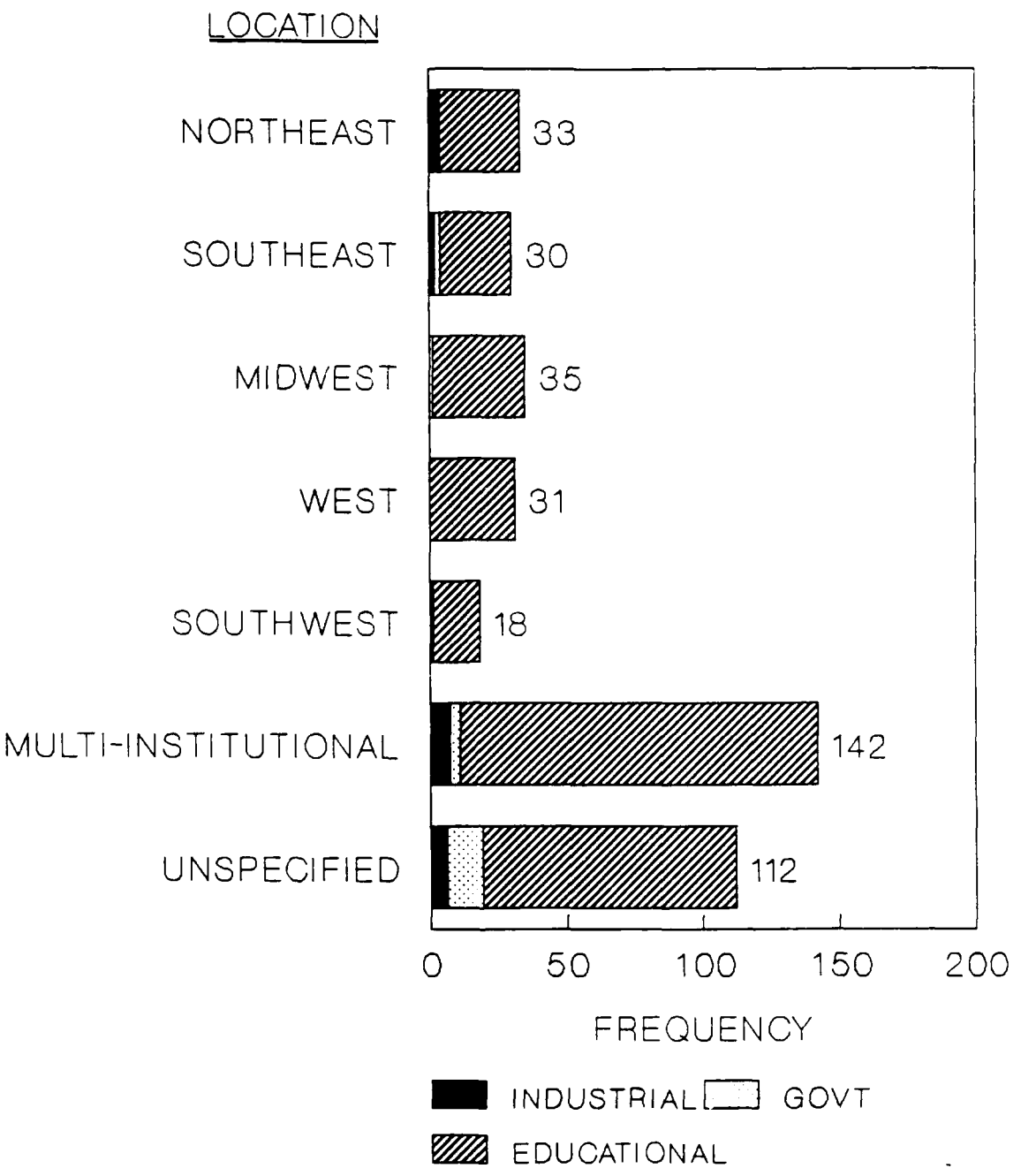

Figure 2. The Distribution of Primary Documents by Location and Setting

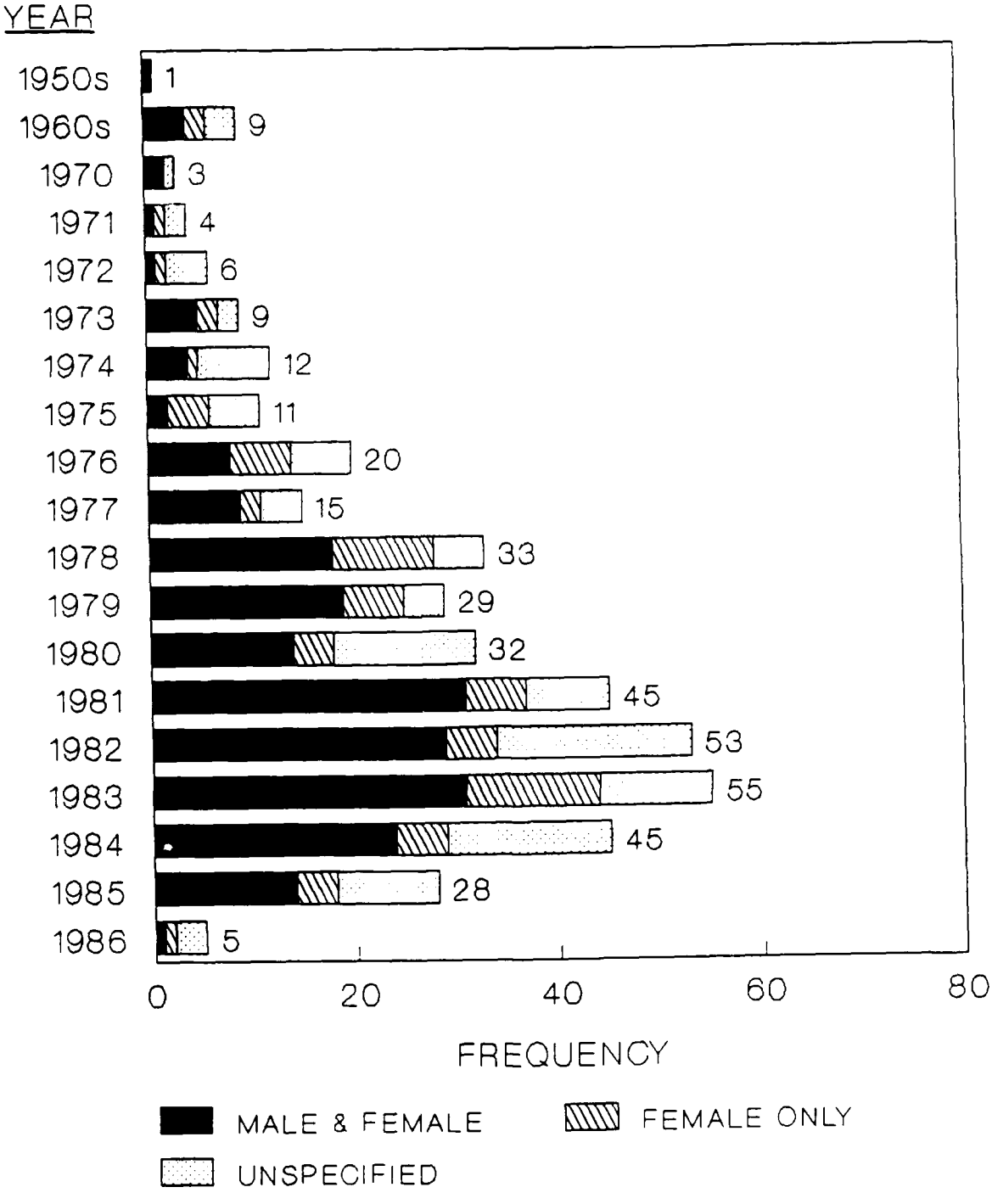

Figure 3. The Distribution of Primary Documents by Year of Publication and Sex of Population

TABLE 1

All Documents by Sex and Race/Ethnicity

Population	Number of documents				
	Males and Females	Males	Females	Not Specified	Total
American Indians	13	1	2	35	51
Anglo	27	0	8	19	54
Asian Americans	13	0	1	22	36
Black	45	1	4	48	98
Hispanic	29	0	3	46	78
Other	7	0	0	4	11
Mixed Minority	6	0	0	8	14
Unspecified	217	1	108	104	430
All Studies	276	2	120	284	682

Americans, and do not receive as much financial assistance in the form of support from academic institutions through teaching and research assistantships. This different pattern results in stereotyping of minorities and women as drop-outs and "unmotivated" and "lazy."

- Math and science are elitist subjects because of the emphasis on the "gifted" and "talented" rather than on the "average" and "normal." The prevalent view is that one is gifted in mathematics or science in the same way that one is gifted in music; and therefore, without this "gift," a person is unable to pursue a career in math or science. Yet minority and female scores on the SAT in mathematics go up as the number and difficulty of courses taken increases. Many programs continue to focus on identification of minorities who <u>are</u> gifted in math and encouraging those students to pursue quantitative careers. The stereotype has become that the opposite of "gifted" and "talented" is "lazy" and "dumb," whereas in fact, the opposite is "average" and "normal." The average and normal student, particularly among minorities and women, is an underutilized human resource in America. The "elitist" mind-set of those who recruit students for math and science careers is a negative factor in the encouragement of women and minorities.

- Retention is the greatest problem in increasing the number of women and minorities. <u>Retention</u> is the problem of the institution or organization, whereas <u>persistence</u> is the problem of the individual student or employee. If we only retain those who are already found to be capable by the present criterion--the mathematics SAT scores--we would have a noticeable improvement. It is not cost effective to recruit larger numbers into SET study and careers only to have them drop out because of unknown factors. Rather, the sensible course of action is to determine what is causing the lack of persistence and deal <u>first</u> with those factors, thus increasing retention. Currently, much of the recruitment effort is wasted as students are not being retained once they are recruited. An additional finding related to recruitment is that most of the interventions connected with recruitment are basically consciousness-raising interventions or programs for career awareness. These are frequently a one-time experience for students with no follow-up or longitudinal measuring of the effect of the exposure of these students to SET studies and careers. Therefore,

much recruitment effort has the potential to be wasted if we do not determine the long-term or length of impact of these recruitment strategies. The data suggest that persistence in SET study and careers varies by sex and race/ethnicity. It may be that although initial efforts are promising, there is a high "evaporation" rate of recruitment results.

- Changing demographics call for changing strategies. The failure of present strategies to materially increase the numbers of underrepresented minorities and women entering SET study and potentially SET careers indicates that the present strategies are ineffective in the face of changing demographics in the United States. The present strategies were based on the "baby-boom," whereas the United States is heading for a "baby-bust." Thus, using math and science courses as "screening" mechanisms to flunk out a large proportion of the class is wasteful during a time when there is a shortage of students. The "open access-closed graduation" syndrome was based on Social Darwinism; i.e., the survival of the fittest. But in today's environment, where the number of 18-to 24-year olds will be reduced by 25% by 1990, such behavior is maladaptive. The new strategy should be based on conservation rather than competition.

- Foreign nationals are increasing as a percentage of the quantitatively oriented student populations at American universities and colleges. Table 2 shows that in the physical science PhDs, the numbers of foreign nationals numbers increased from 12.3% of the total in 1960 to 26.4% of the total in 1984, a trend likely to continue. The situation is even more serious in engineering (see Tables 3, 4, and 5). Nearly 39% of all the engineering PhDs awarded in the United States in 1984 went to foreign nationals--while the underrepresented minorities received only 1.5%. Adding women brings the total to 6.2% of the 3,234 total number of PhDs. This direction has important ramifications for the make-up of the scientific and engineering work force. The literature indicates that although this increase is being monitored, no policy decisions are being made about the effects upon the United States education and work force of this large foreign component. Indications are that foreign professors and teaching assistants have a greater impact on minorities and women than white males, especially when the faculty members are from

TABLE 2

Number of Ph.D. Recipients in the Physical Sciences by Type of Citizenship, 1960-1984

YEAR	TOTAL	U.S.	FOREIGN			Citizenship not Known
			TOTAL	Immigrants	Non-Immigrants	
1960	1,861	1,619	229	51	178	13
1961	1,993	1,696	269	48	221	28
1962	2,097	1,812	262	32	230	23
1963	2,428	2,045	333	55	278	50
1964	2,527	2,130	343	74	269	54
1965	2,865	2,418	411	85	326	36
1966	3,059	2,526	446	88	358	87
1967	3,504	2,891	540	124	416	73
1968	3,671	3,073	527	130	397	71
1969	3,919	3,251	581	170	411	87
1970	4,404	3,631	709	275	434	64
1971	4,501	3,689	737	330	407	75
1972	4,233	3,348	819	373	446	66
1973	4,021	3,098	856	348	508	67
1974	3,709	2,743	809	302	507	157
1975	3,631	2,734	813	269	544	84
1976	3,442	2,619	765	247	518	58
1977	3,410	2,623	720	213	507	67
1978	3,234	2,494	670	206	464	70
1979	3,321	2,570	685	199	486	66
1980	3,151	2,393	682	176	506	76
1981	3,208	2,419	683	160	523	106
1982	3,348	2,511	733	146	587	104
1983	3,438	2,544	794	149	645	100
1984	3,459	2,546	913	142	671	100

SOURCE: Foreign Participation in U.S. Science and Engineering Education and Labor Markets, Special Report NSF 81-316, National Science Foundation, September 1981; and 1980-1984 Summary Report, Doctorate Recipients from United States Universities, National Research Council, 1981-1985

TABLE 3

Engineering Degrees by Level, Sex, Race & Citizenship, 1984

	BACHELOR'S		MASTER'S*		Ph.D.	
	Number	Percent	Number	Percent	Number	Percent
Total	76,931	100.0	21,228	100.0	3,234	100.0
Women	10,761	14.0	2,149	10.1	153	4.7
Black	2,022	2.6	257	1.2	24	0.7
Hispanic**	2,038	2.6	364	1.7	25	0.8
Asian/Pacific	5,609	4.7	1,394	6.4	267	8.3
American Indian	112	0.1	25	0.1	0	
Foreign National	5,833	7.6	5,728	27.0	1,253	38.7

*Includes Engineer Degrees **Includes 355 B.S. and 9 M.S. at U. Puerto Rico

TABLE 4

Percent of Engineering Bachelor's Degrees Awarded to Women and Minorities

	1974	1976	1978	1980	1982	1984
Women	1.80	3.62	7.11	9.67	12.15	13.99
Black	1.83	2.05	1.94	2.25	2.49	2.63
Hispanics*	1.56	1.81	1.91	1.72	1.91	2.20
Asian/Pacific	2.31	2.83	2.59	3.27	3.85	4.69
American Indian	0.08	0.11	0.08	0.10	0.14	0.15
Foreign National	5.88	7.37	6.69	8.33	8.08	7.58

*Exclusive of the University of Puerto Rico

TABLE 5

Percent of Engineering Degrees Awarded to Foreign Nationals

	B.S	M.S.	Ph.D
1974	5.88	19.,51	30.16
1975	6.45	20.61	29.32
1976	7.37	22.36	35.61
1977	7.47	23.11	35.36
1978	6.69	22.99	33.97
1979	7.20	25.24	33.00
1980	8.33	26.17	35.70
1981	8.93	26.11	37.10
1982	8.08	28.50	40.42
1983	8.49	29.84	39.43
1984	7.58	26.99	38.79

SOURCE: Engineering and Technology Degrees 1974 through 1984, Engineering Manpower Commission

countries where women hold subservient status and minorities are considered inferior.

- Occupational segregation is still a factor in the American workplace and has an adverse effect on the persistence of women and minorities in SET study and careers.

- The data suggest that there is a generalized condition which we have termed Occupational Adaptation Syndrome (OAS). OAS is a biocultural rubric covering a wide range of problems encountered by women and minorities in college and careers which can be ameliorated by intervention strategies. Cultural stereotyping, which is prevalent for women and minorities, is the beginning of the OAS for women and minorities. Although differing from overt discrimination, stereotyping has replaced racism and sexism. The prevalence of stereotyping indicates that barriers have not been eliminated from educational institutions and organizational work places. Stereotyping sets off a cycle of behaviors which frequently end in drop-out and stop-out. The symptoms frequently described in the literature by minorities and women are anxiety, alienation, isolation, disorientation, inability to concentrate, and other symptoms which significantly affect the student's ability to function and maintain health. Math and science anxiety may be examples of OAS. Experiences <u>outside</u> the classroom can have an impact upon academic performance and career choice. (For a review of this issue, see "Out of the Classroom: A Chilly Campus Climate for Women," by Roberta M. Hall and Bernice R. Sandler, 1982.) Aspects of OAS may also relate to the role of education in technological change as developed in a model for NSF by the Rand Corporation (1976).

- Case studies and interview findings corroborate the OAS hypothesis. Preliminary findings also indicate that women engaged in quantitative careers are "late bloomers" and perceive themselves as "loners." Perceptions of minority male incumbents are that they are viewed as less capable than majority engineers, that promotions slow down after the first 7 to 10 years, and that management positions are rarely offered to them.

- There are differences between other developed countries and the United States in attitudes towards engineers and teachers of science which need

to be investigated more thoroughly as these may be hindering the progress of women and minorities.

- Few intervention strategies or programs have evaluation data. This is a handicap in assessing the efficacy or cost-benefits of the existing intervention programs.

The Prototype Longitudinal Study Plan (PLSP)

The CASET Study was conceived as a 5-year multiple phase research project in order to gather and evaluate longitudinal data on minorities and women as they proceeded through the processes of SET recruitment, selection, performance, retention, graduation, and employment. Part of the mandate for Phase I was the development of a plan for a longitudinal study to commence after the literature search and interviews of Phase I. Building upon previous research and not reinventing the wheel were essential concepts in the study's research design.

Based on rates of participation, it has been clear for some time that some form of active intervention is necessary to increase the numbers of minorities and women in the SET pool. The SET pool reflects neither the composition of the general population nor the workforce in terms of sex and/or race/ethnicity. The CASET literature search found published reports on approximately 100 interventions, but investigators learned that there are many more interventions listed on "inventories" of special programs and resources for the underrepresented groups of American Indians, Blacks, Hispanics, and women (for example see Aldrich and Hall, 1980; Gordon et al., 1986; Department of Education, 1984; Malcom, 1984; Malcom, Hall & Brown, 1976; National Actionl Council for Minorities in Engineering, Inc., 1984; National Science Board Commission on Precollege Education in Mathematics, Science, and Technology, 1983; Office of Technology Assessment, 1985). These unpublished interventions have data which fall in the category of "fugitive intervention data." They need to be located and placed on the CASET data base. The interventions may never have been evaluated and probably do not include an evaluation component in the research design. Additionally, there are very few follow-up or longitudinal studies monitoring the people who have participated in some form of intervention program. For this reason, there is a need to pilot-test future interventions and to conduct a longitudinal study of both students and incumbents in order to determine what difference interventions make. Another research need is to discover what happens to the drop-outs; i.e., the reasons for nonpersistence in a SET subject area and what alternative career plans are made.

Since the number of documents found was over twice as many as had been anticipated, the Advisory Group concurred with CASET personnel in advocating a Phase II effort to address the research question of factors and interventions through quantitative synthesis, such as meta-analysis. Lantz, Carlberg, and Eaton (1982) pioneered the use of meta-analysis in looking at women's choice of science careers. They found that women in science careers were similar to male counterparts but different from women choosing non-science occupations. Also, these researchers found that the difference between women choosing science and other women was much greater than the difference between women choosing engineering and other women.

Phase II

As the research made increasingly clear, the large number of empirical studies on the CASET study subject called for quantitative synthesis rather than a more usual literature review approach. Phase II was initiated as an overlap with Phase I for cost avoidance purposes through early modification of the coding sheet to facilitate coding for quantitative synthesis as well as data base construction.

Phase II will use meta-analysis to provide a synthesis that extends statistical techniques in order to state which interventions are most effective and most influential. Phase II may also provide a cost-effective or impact analysis of the interventions reported in the literature which have been found by the independent researchers (through statistical analysis or other evaluation) to be most successful.

NASA Memorandum of Understanding (MOU). Because of the computer-intensive nature of Phase II and the Completion Phase, an MOU will be signed between Huston-Tillotson College and the National Aeronautics and Space Administration (NASA)/Johnson Space Center (JSC). The MOU provides for JSC provision of mainframe host computing time, software systems, and technical personnel on an as-available basis.

The major issues CASET will address in Phase II include the following:

- o identification of the factors which are identified as influential or important in the selection by women and minorities of SET careers;
- o identification of specific interventions (i.e., program elements) associated with these factors; and
- o the impact of the interventions (benefits) compared with the costs.

One area of data that has not been previously tapped is that of dissertation research. Many dissertations addressing technical issues have been funded by the Department of Labor (DOL). In Phase I, CASET identified 625 dissertations which could not be found in libraries or obtained through Interlibrary Loan. Additionally, many reports were found which needed to be purchased from the NTIS, DTIC, and other data bases. The DOL provided funds for the purchase of these materials. The data contained therein will be especially useful in the Phase II quantitative synthesis.

Phase II field research will also consist of the development of plans for field testing the interventions found most successful through quantitative synthesis, with implementation following on in future phase(s). Future research will focus on intervention modules to be located in colleges with participating populations of American Indians, Blacks, Hispanics, and/or women. The methodology would be comparative rather than experimental. The duration of each intervention would be one semester and/or one summer, if the intervention were an industry internship or an intensive "immersion" program. The interventions would be categorized in two groups: 1) industry or defense installation consisting of some form of internship or on-site career-related learning experience and 2) academic or assessment center related, consisting of a variety of learning experiences that can take place in an academic environment but that in fact may be experiential/discovery in nature, rather than traditional academic and remedial courses.

Phase II will examine cost-effectiveness components for those programs found most successful in order to provide a cost benefit effectiveness analysis of the interventions which have been documented through the literature review. Where possible, these would be costed relative to the benefits claimed by the institution, the length of time of the program, the number of students, faculty, and staff involved.

Completion Phase

The focus of the Completion Phase is twofold: 1) pilot testing of the interventions which have been designed and developed to fill in research gaps identified in Phases I and II; and 2) conducting field tests of the interventions on a longitudinal basis for the purpose of monitoring participants over time.

After identifying the vast amount of literature on the subject and anticipating the quantitative synthesis to discover which interventions have proved most successful with which groups, it is hoped that the Completion Phase will be able to demonstrate cost avoidance results by evaluating on-going

programs found to be successful as well as field-testing new interventions. At this time, it is not possible to identify such programs, but preliminary findings suggest that the programs operated by the National Action Council for Minorities in Engineering, Inc. (NACME), are among the most successful. Following a methodology of evaluating research either already accomplished or in process, as well as developing and testing new interventions to fill research gaps, the Completion Phase will be composed of the following research strategies:

- Intervention modules will be tested with members of the CASET Consortium, to be composed of selected colleges and universities with predominantly or historically underrepresented minority and/or female populations.

- Symposia focusing on the study research questions will be held at NASA/JSC. The literature search has revealed a gap in the data on subgroups defined by both gender and race/ethnicity; e.g., black females, American Indian males, etc. However, the 625 dissertations purchased with the support of the DOL contain a wealth of related data on these populations researched by scientists with field experience, many of whom will be invited to participate in the symposia. Separate symposia will be held for American Indians, for Blacks, and for Hispanics; and three advisory committees will be formed to review the policy and program recommendations.

- Ongoing programs will be analyzed and evaluated, with monitoring of students presently in the programs. For example, program data from NACME on 5,000 engineering graduates and about 6,000 current minority engineering students will be analyzed and compared with all other CASET data.

- Hypotheses developed through the meta-analysis, other data analysis, and symposia will be tested against primary data collected by the DOL's National Longitudinal Survey (NLS), and the Department of Education Center for Educational Statistics' "The Class of '72" and "High School and Beyond - '80 and '82," as well as other longitudinal surveys. These surveys are stored on magnetic tapes whose acquisition was supported by the DOL, and we will be using the NASA/JSC computer facilities for retrieval and analysis.

- Interviews will continue with SET incumbents, students, employers, educators, and counselors to add more case studies to the data collection. Related research linkages with NASA, Army Civilian

Personnel, military installations such as Ft. Hood, and aerospace and defense contractors will provide appropriate opportunities for field pre-testing of intervention materials and methods.

The research questions will continue to be addressed; however, the findings of Phase I have raised some new issues which will also be investigated:

- Occupational segregation, subsuming barriers dealing with study and career recruitment and selection.
- OAS, subsuming barriers dealing with retention and performance in SET study and careers.
- The relationship between the rapidly increasing numbers of foreign nationals in American colleges and universities, both as students and faculty, and the continuing decline in the number of Blacks and Hispanics in American colleges and universities, both as students and as faculty.
- Current research gaps for subgroups defined by both sex and race/ethnicity.

Texas as a Primary Location for Field-Testing

Texas is eminently suited as the primary location for the intervention field-testing because it has a unique combination of conditions necessary for the conduct of this research. First, Texas has large enough Black and Hispanic subgroups to be significant in relation to each other (see Figure 4), and these populations are more evenly represented than in other high-minority states. A recent research report published by the National Institute of Independent Colleges and Universities (1984) shows Texas as having a minority population of 45.9% being surpassed only by the District of Columbia and Mississippi, which are heavily Black, and Hawaii, heavily Hawaiian and Pacific Islander. Additionally, the American Indian population in Texas is primarily urban and compares favorably quantitatively with other states.

Second, the work force in Texas is reflective of the general population with the Anglo work force being in fact a smaller percentage of the total than of the workforce: 70.8% of the workforce against 78.6% of the population for males and 69.7% of the workforce against 78.7% of the population for females.

Third, Texas is the location of over 2,000 defense industry sites and installations employing large number of SET professionals and technical personnel. The state is strongly

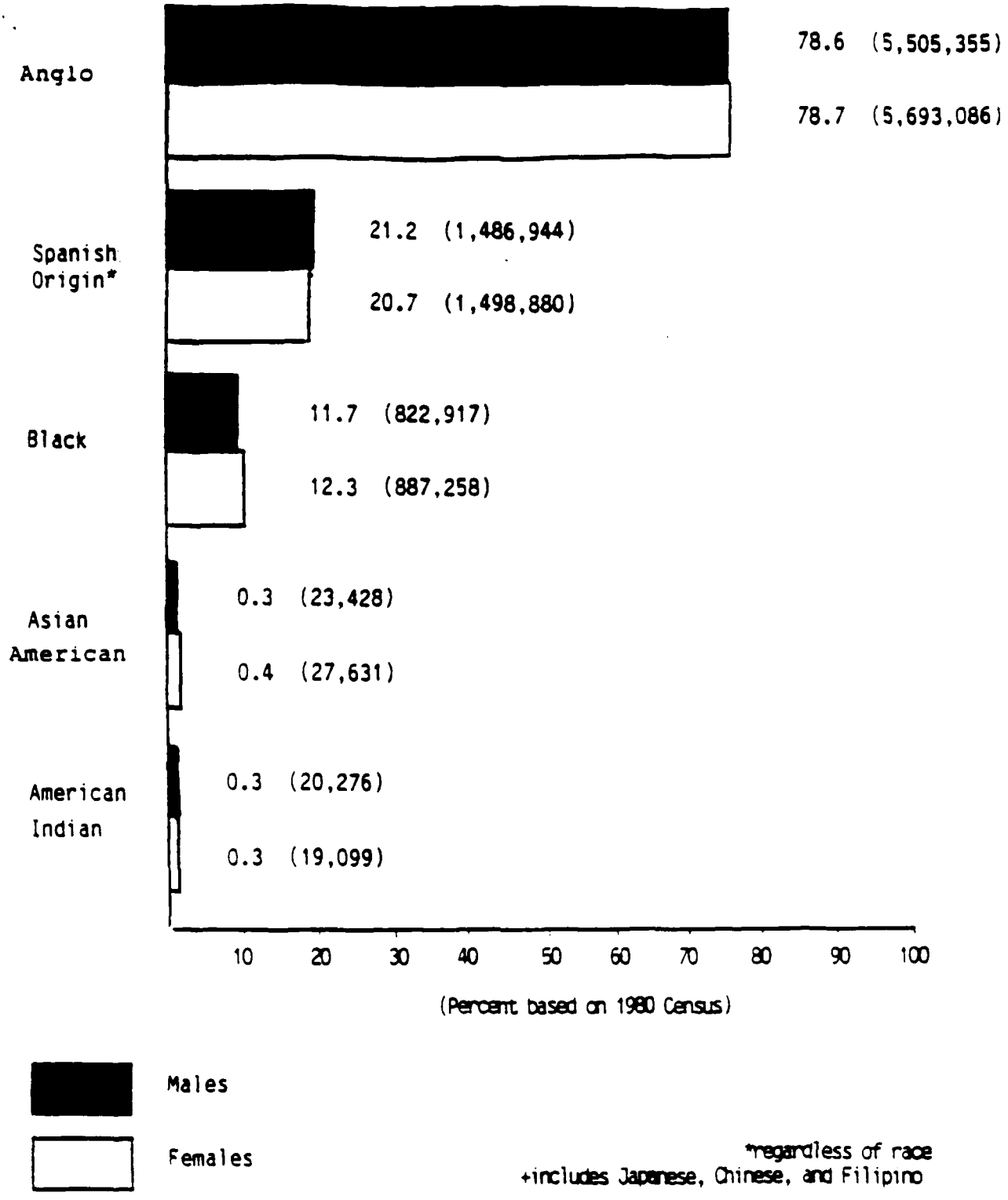

Figure 4

TEXAS POPULATION

committed to private sector cooperative efforts between industry and academia. A recent poll found that Texans believe business and industry should help pay for research in science and technology (Public Policy Resources Laboratory, 1985).

Texas has 22 small, predominantly minority or female private colleges and universities. Many science and engineering PhDs who are also women or minorities took their undergraduate degrees in institutions having these characteristics.

Texas demographics. As the percentage of the minority population increases, the "demographic destiny" of America may begin to resemble that of Texas. In Texas in 1980, the total population was 14,229,000. Anglos comprised 78.70%, 20.98% were Hispanic (irrespective of national origin), 12.02% were Black, 0.28% were American Indian, and 0.82% were Asian. While the Texas population has a slightly higher percentage of Blacks and slightly lower percentage of Asians and American Indians compared to the national figures, the Hispanic population in Texas is notably larger than the national, 20.98% compared to 6.4% or more than three times greater than the national figure (See Figure 5). The Hispanic population in Texas represents 20.5% of all Hispanics in the United States, and 75% of Mexican Americans live in California or Texas.

The male and female ratios within each group are very close in number with females slightly outnumbering males except for American Indians. The largest discrepancy between the sexes are within the Asian Americans, where the females outnumber the males by approximately four thousand. In total, females outnumbered males slightly with just over 7 million while males numbered just under 7 million.

In a major Texas city such as San Antonio, 53.7% of the population in 1980 was Hispanic; San Antonio ranked fifth in the nation for numbers of people of Hispanic origin. A smaller metropolitan area such as McAllen-Edinburg-Mission had an even larger percentage of Hispanics, 61.9%. Other Texas cities with a large percentage of Hispanics included Corpus Christi (48.5%), Odessa (42%), and Victoria (30%).

With respect to the Black population in Texas, Houston ranked ninth among other major cities in the United States, with 18% Black population. Dallas, another major city in Texas, ranked sixteenth in the nation with a 14% population that is Black. The other cities in Texas with a considerably large Black population in 1980 include Ft. Worth (10%), Austin (9%), Tyler (21.9%), and Beaumont-Port Arthur (21.8%).

In Texas, by the year 2000, 36% of the children between the ages of 5 to 14 are projected to be of Spanish origin. Blacks under the age of 15 are projected to comprise around 15% of the

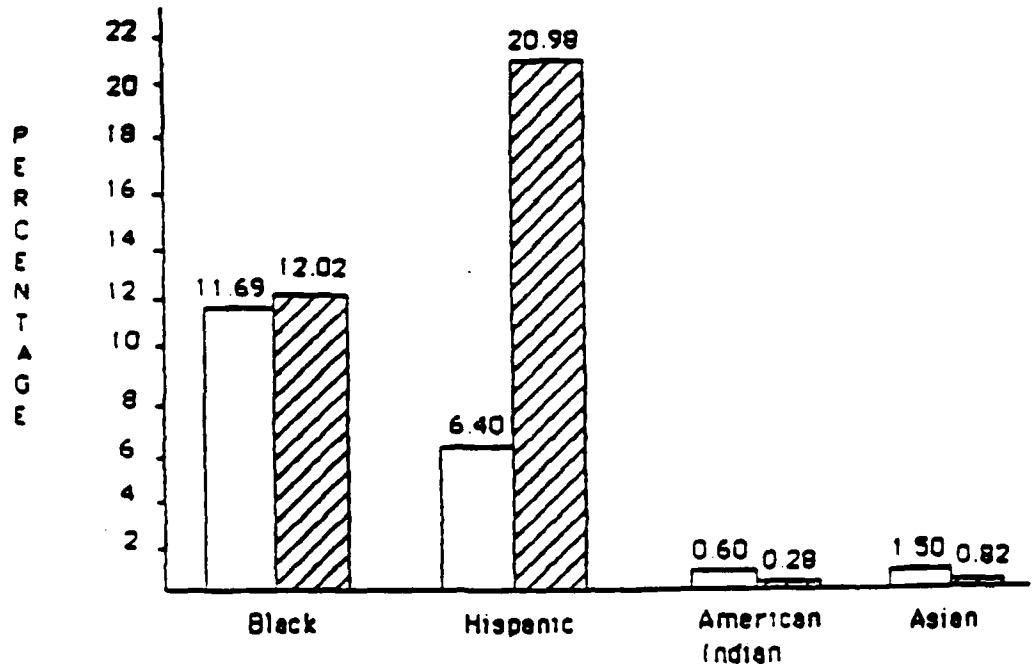

Figure 5 Minority Population - National and Texas

Based on 1980 U.S. Census

state's population. In sum, this means that approximately 50% of Texas' school children will be either Black or Hispanic in 2000. Adding the minority groups of American Indians and Asian Americans will make Anglo children the minority in the public schools for the first time.

Post-Secondary Education

Although, from preschool through twelfth grade, more males than females were enrolled across all of the groups, by graduation the Hispanic subgroup contained more females than males. According to figures collected by the Texas Coordinating Board from the 1984 fall headcount of freshmen in public senior colleges and universities, there were more Black, Hispanic, and American Indian freshmen who were females. However, for Anglos and Asian Americans, the male population was greater.

With respect to the college enrollment of racial/ethnic groups, Anglos represented about 70%, Hispanics only 14%, Blacks 12%, and American Indians less than three-tenths of 1%. Asians represented 2% (see Figure 6). In undergraduate engineering enrollment, Texas exceeds the national figures for total minority, Black, and Hispanic enrollees (Figure 7).

The profile of seniors in Texas colleges and universities in 1984 shows another increase in the percentage of Anglos continuing education, nearly an 80% representation. There was a steady decline of Hispanics, 11% of the college seniors, and a decline of Blacks, down to 6%. Asian Americans maintained their 2% representation as they did as freshmen. American Indians were still as poorly represented as they were in the freshman class.

With respect to the gender of the students, the trend was the same as it was with the freshman class, except among seniors there was a reverse among the American Indians. Male American Indian seniors outnumbered the women, but only by four students.

Texas Enrollment in Science, Engineering, Math, Computer Science, and Technology-Related Fields. The headcount of doctoral students in Texas as of 1985 showed an increase in Anglos, a slightly higher representation of Asians in engineering and computer science, and a great decline among the Blacks and Hispanics. These latter two groups do not show over a 1% representation. American Indians remained fewer than 1% of these students.

According to figures generated by the fall 1985 headcount of public senior colleges and universities, Anglo males have a strong hold in the science, engineering, and technology-related

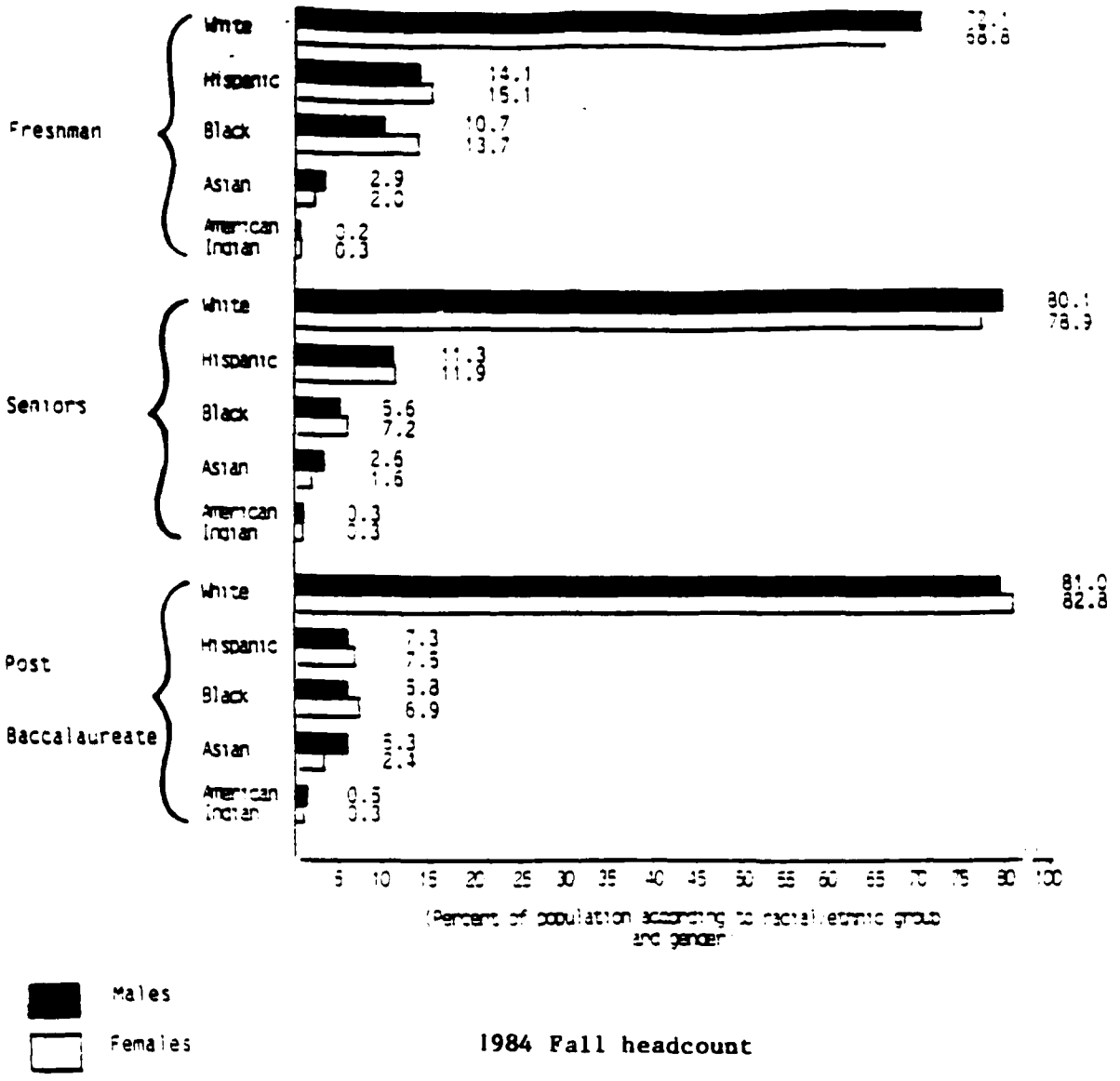

Figure 6 Enrollment in Texas Public Colleges and Universities

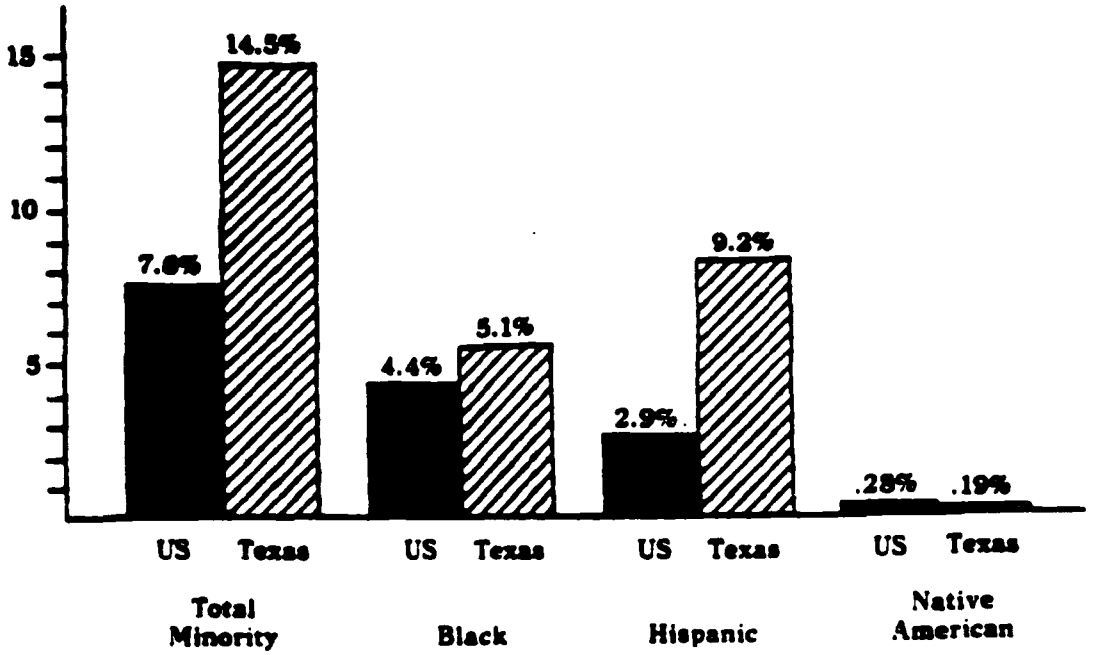

Figure 7 1983 Minority Undergraduate Engineering Enrollment (as Percent of Total Engineering Enrollment)

Source: 1984 TAME Annual Report

fields of study. This is true of the undergraduates and even more so for the doctoral students.

Anglo undergraduates represented upward of 70% (in technology) to an 84% representation in the physical/environmental sciences. Females represented an almost equal number of the Anglo students only in math (46%).

Black representation is highest in the technology-related fields of study, 20%. Their lowest representation, only 3%, is in the physical/environmental sciences.

The Black sex ratio is more equivalent than for the other racial/ethnic groups, across all areas of study. Black females' lowest participation is in technology--17%. They have a 32% representation in engineering, 46% in both the physical/environmental sciences and in math, while they surpass male representation in the computer sciences with a 52% representation.

Hispanic representation ranges from 5% in technology to a high of only 13% in engineering. The most favorably chosen field by Hispanic females was math, where they represented 36%.

American Indians were so few in number in all of the mentioned fields that they constituted less than 1% in each field. Furthermore, men dominated the American Indian enrollment. Females did reach a 31% representation in the physical/environmental sciences and a 25% representation in the computer sciences.

Asians and Asian Americans did not comprise a very large percentage of students enrolled in science, engineering, or technology in the Texas colleges and universities. They were typically at or below Black representation. Their largest representation was in engineering at 7%; there were always a greater number of males than females. The greatest number of Asian and Asian American females were in the computer sciences, 39%.

Female enrollment also declined severely. At times, males had a 100% representation. This was true for Black and Hispanic males in the computer sciences and in math. Black women held a 25% representation, however, in the engineering and physical/environmental sciences. Asian and Asian American women represented 34% and 40% of the physical/environmental and math students, respectively. Anglo females reached their highest representation, 23%, among mathematics students.

In the science, engineering, and technologically related fields of employment, according to figures calculated by the Texas Employment Commission, Anglos (in particular, Anglo males)

dominate. Anglos represent at least 80% in each of these areas. Their lowest percentage, 80%, is in the technology-related positions. There is also an 80% to 20% representation of males to females employed in this field.

Anglos are 86% of those employed in mathematics. However, in mathematics there is a higher representation of females, 36%. In both engineering and computer science, Anglos have an 88% representation. Females reach almost 20% in computer science, but they had a low representation of 4% in engineering.

Between the other groups of interest--Hispanics, Blacks, American Indians, and Asian Americans--the representation is obviously low. Female representation is also consistently low across all of these fields and all groups, with a few exceptions.

Regarding the racial/ethnic groups' representation, the most notable or anomalous statistic is that Blacks reached a 6% representation in the technology-related fields and Hispanics reached a 10% representation.

In Texas, some minority women are approaching men in SET enrollment. Of Blacks enrolled in computer science, 44% are women while American Indian women constitute 58% of that group's representation in mathematics.

Minorities and Women in SET Careers

The data on Texas employment are based on 1980 U.S. Census Bureau population data and therefore includes persons who reside in the United States and foreign nationals[1] (Appendix F). In quantitatively based fields, Anglos--particularly Anglo males--dominate (Figure 8).

In Texas, the percentage of women employed in science and engineering fields (11%) is somewhat higher (Figure 9) than it is nationally (4%), while for minorities the percentage is lower (12% as compared to 14%) (Figure 10). These figures, based on the 1980 Census and calculated by the Texas Employment Commission in 1983, were approximately 11% for women. Science/engineering defined here includes only the physical/environmental sciences, engineering, mathematics, and computer science. If technology is included in the Texas data, the percentage increases to 15% for both women and minorities. As in higher education nationally and

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[1]The "Black" category may include nationals of other countries; the "Hispanic" category may include foreign nationals, both documented and undocumented; and the category "Asian descent" refers to U.S. citizens, refugees, and foreign nationals from South and East Asia.

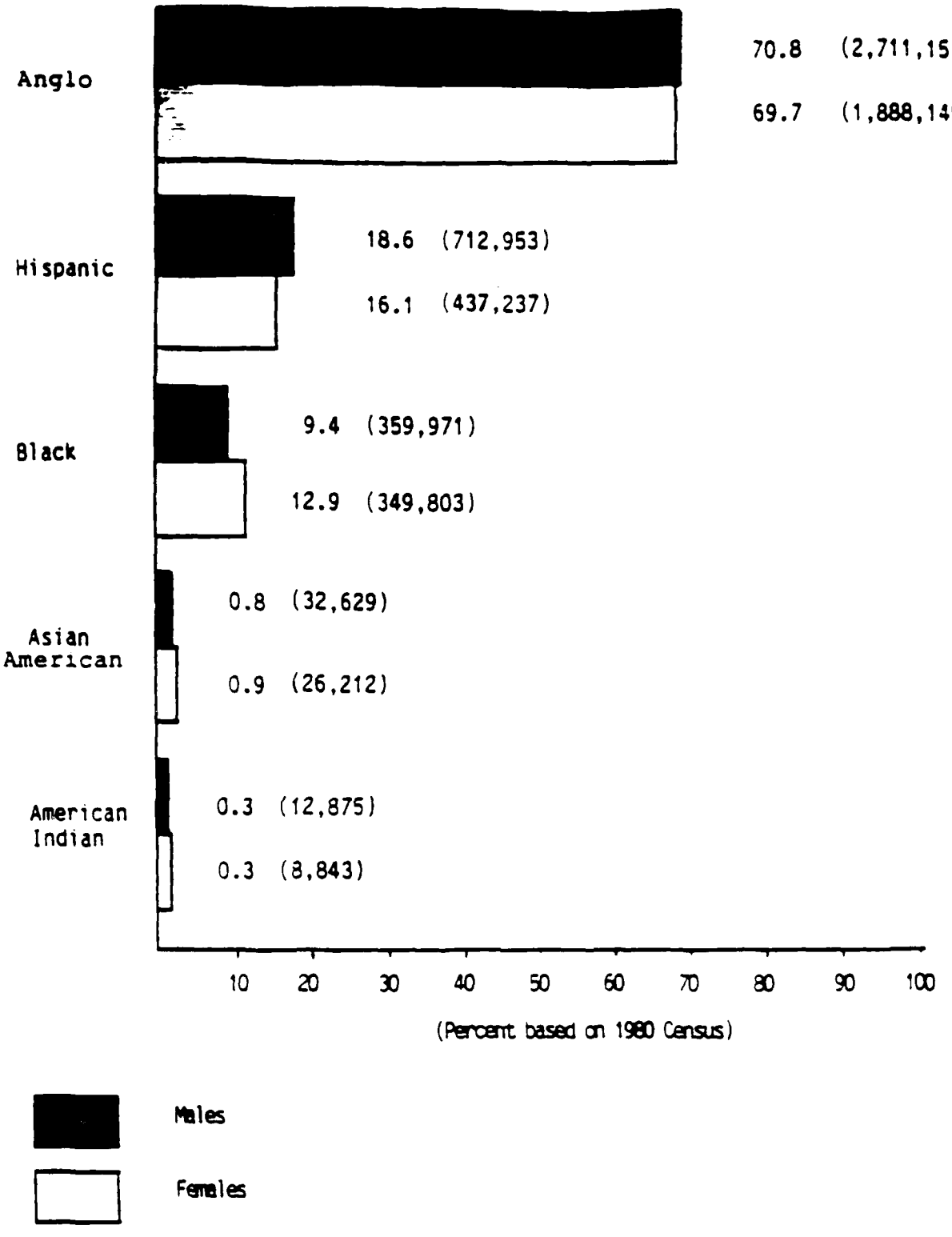
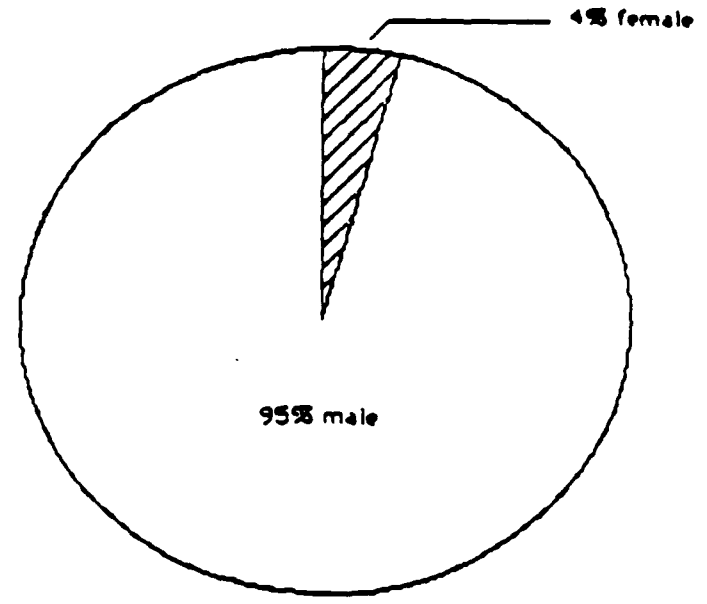
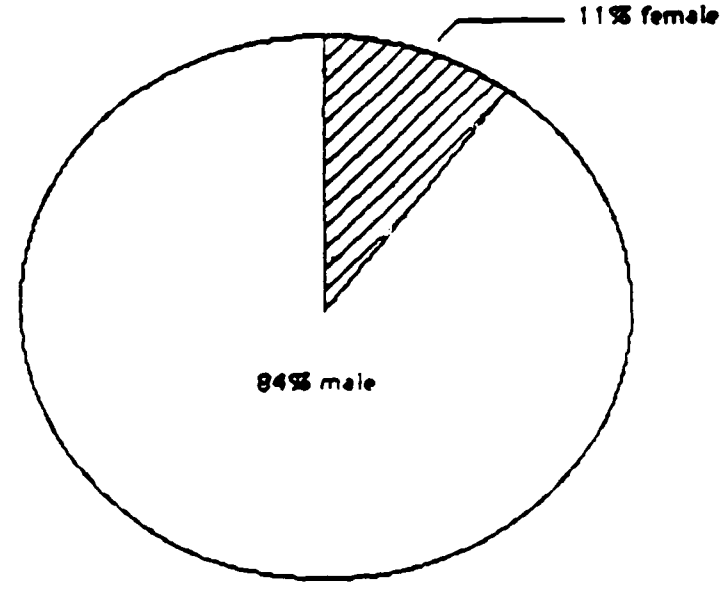


Figure 8

TEXAS EMPLOYMENT



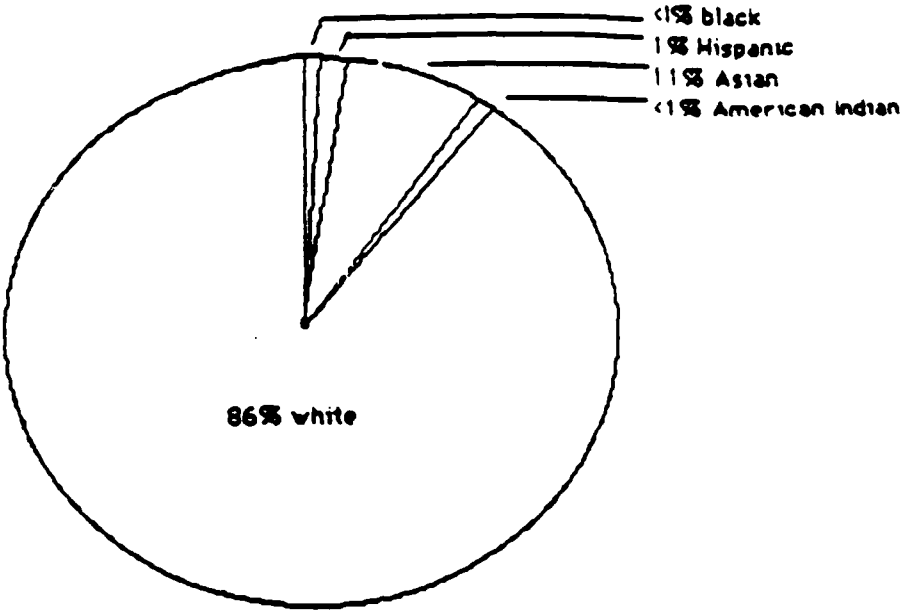
National



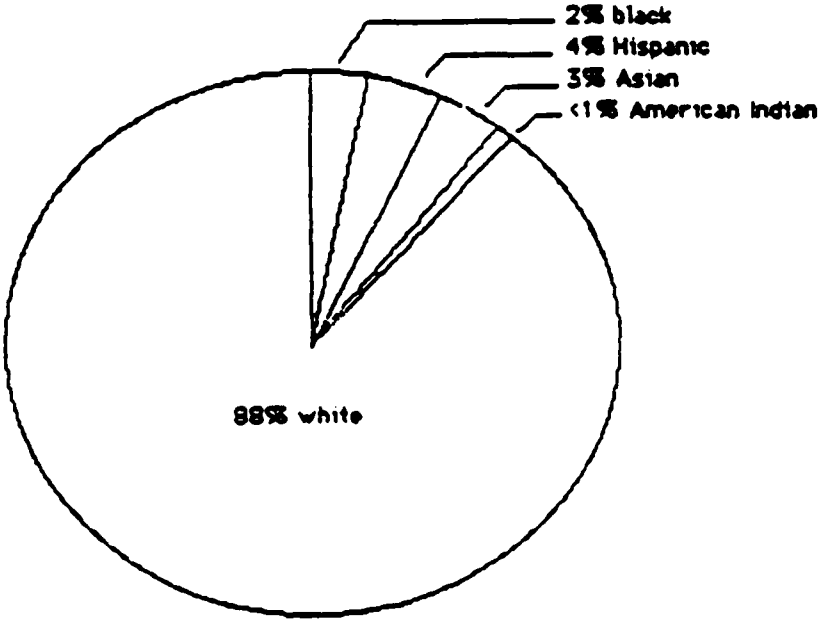
Texas

Figure 9 Women Doctorates Employed Full-Time in Science/Engineering
National and Texas - 1983

National data based on National Science Foundation Statistics
Texas data based on Texas Employment Commission Calculations from
1980 U.S. Census data



National



Texas

Figure 10

Minority Doctorates Employed Full-Time in Science/Engineering
National and Texas - 1983

National data based on National Science Foundation Statistics
Texas data based on Texas Employment Commission Calculations from
1980 U.S. Census data

in Texas, and in the national science/engineering workforce, women's largest representation is in mathematics with 35%. They also have a relatively high percentage employed as technicians, 21%, and computer scientists, 20%.

For both Hispanics and Blacks, their highest representation is among technicians (i.e., electrical and electronic technicians, engineering technicians, and computer programmers), 10% and 6%, respectively. The next highest SET career representation for Blacks and Hispanics is in mathematics, with 5% and 6%, respectively. Asians are most highly represented in engineering, while this is the occupational field with the lowest percentage of Blacks in Texas (2%). American Indians in Texas, as was true for their national standing, constituted less than 1% in all science/engineering occupations.

DISCUSSION

The CASET Data Base

Data Base Documents. THE CASET data base contains 417 primary documents. Primary studies are those in which the author interacted with the population to gather data (as opposed to secondary studies, in which data has been gathered by researchers other than the authors). A primary study may include primary case history or anecdotal data (as opposed to an empirical study). Because secondary and nonempirical documents are of less importance to this research, the findings discussed below will deal mostly with the primary and empirical documents.

Document Types. The predominant type is the journal publication; 50% of all primary articles were found in scientific and professional journals. Papers from conferences and proceedings were the second most prevalent (16%) type; most of these were delivered at annual meetings such as the NASA Space Sciences Symposium or conventions of the American Psychological Association. College reports, on the programs or activities of a particular college or university, and government reports from governmental institutions such as the National Science Foundation constituted 8% and 9% of the total, respectively.

"Other" documents (10%) included reports authored or published by professional societies and associations, such as "The Participation of Women in Scientific Research," from the American Association for the Advancement of Science (Brown et al., 1978) or by private institutions, such as "Mexican American and Puerto Rican Prospective Engineering Students," from The Latino Institute of Reston, VA (Berry-Caban, 1982). Masters' theses, high school reports, and data tapes were also classified as Other document types.

Books, chapters from books, reports from industrial or business organizations, instructional or teaching materials, and manuals and handbooks each made up 1% to 3% of primary documents. No dissertations, unpublished manuscripts, bibliographies, or audio-visual materials were found or included as primary documents at this state in the formation of the data base.

The distribution of primary studies was also analyzed by location and research setting. Five regions of the United States were defined, by states, so that the Northeast region included Maine, Vermont, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, Pennsylvania, New Jersey, and Delaware; the Southeast region included Arkansas, Louisiana, Kentucky, West Virginia, Virginia, North Carolina, South Carolina, Tennessee, Mississippi, Alabama, Georgia, Florida, and Maryland; the Midwest included Minnesota, Wisconsin, Iowa, Illinois, Indiana, Ohio, and Missouri; West included Washington, Oregon, California, Nevada, Montana, Idaho, Utah, Wyoming, Colorado, North Dakota, South Dakota, Nebraska, Kansas, Alaska, and Hawaii; and the Southwest included Arizona, New Mexico, Texas, and Oklahoma.

Studies with region specified were fairly evenly distributed across the Northeast, Southeast, Midwest, and West, with somewhat fewer studies located in the Southwest region of the United States. This difference may be due entirely to the fact that, as defined, the first four regions contain 8 to 15 states each, whereas the Southwest region contains only 4. By far, the highest numbers of documents were located in the "multi-institutional" and "unspecified" categories, accounting, together, for more than 60% of the primary documents.

Of the primary research studies, 90% were conducted in educational institutions. The remaining 10% was evenly distributed among industrial and governmental settings. This overwhelming emphasis on research in educational settings may be due to a widely held belief among researchers that these institutions are overwhelmingly important to SET career choice and success and/or due to the ease of access to them and to student populations for researchers, who are themselves affiliated predominantly with academic departments.

The above analyses excluded 16 documents in other locations and settings For example, a study in which the researcher sent surveys to women engineers whose addresses were obtained through the Society for Women Engineers would be in the "Other" category; it would be a uni-institutional, yet multiregional study, and was not set in an educational, industrial, or governmental institution.

Most primary studies were conducted at two or more (multiple) educational institutions or at educational

institutions with location unspecified. Two-thirds (two documents) of the uni-institutional, region-specified studies done in a governmental setting were located in the Southeast region, which includes the Maryland-Virginia area surrounding the District of Columbia.

Figure 11 illustrates the distribution of all documents in the SET data base by ethnicity of population. Regarding the race/ethnicity of their research populations, most of the documents had to be placed, unfortunately, in the "mixed minority and other" class, essentially an "unspecified" category. The populations were female and male. However, since no specific information on race or ethnicity was given, a heterogeneous population containing Anglos and minorities was assumed. The lack of information on this crucial variable reduces the usefulness of the documents to this project. The "mixed minority" category similarly contains documents specifying only that a "minority" population was used, with no details as to composition by subgroup.

Articles which dealt with more than one population were counted more than once (i.e., a study using Black and Hispanic students would be counted with both the Black population studies and the Hispanic population studies); the total of the articles was, therefore, greater than 682 for this analysis. Nearly 100 studies examined Black populations. Hispanic populations were studied in 78 articles, and Anglo Americans, American Indians, and Asian Americans were represented in 54, 51, and 36 documents, respectively. Blacks were studied in nearly 100 empirical studies making them the most frequently researched group. Although the U.S. Black population is approximately 20 times that of the American Indian, the latter were examined in half as many studies. The proportion of articles on Anglo Americans was also small in comparison to the Anglo population, but this was an effect of the selection criteria for inclusion of documents in the CASET data base. Anglo was not a key word for the computerized data file searches, whereas women, American Indian, Asian American, Black, and Hispanic were. Thus for an Anglo subgroup population to be counted in a document's population coding, it had to be present in a study also designated by one of the five key subgroups. This had the effect of limiting Anglo subgroups in relation to the other subgroups (See Appendix C).

For similar reasons, very few articles were included with male (only) populations. Documents with female (only) populations were distributed mostly among the "mixed minority" and "other" documents and the Anglo American documents. A large proportion of all documents did not specify sex of population; these probably represented mixed-sex groups but were labeled "unspecified." The "male and female" category was reserved by articles that specified a male and female population.

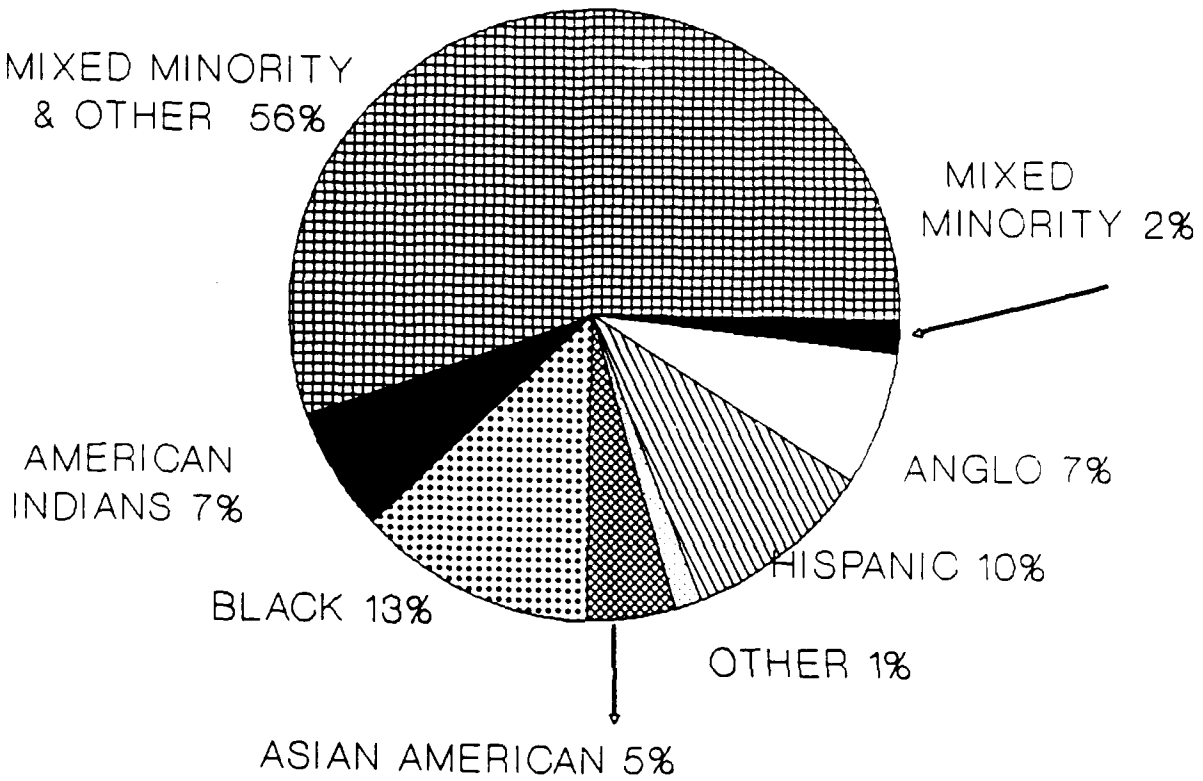


Figure 11. The Distribution of all Documents by Population

Figure 12 shows the publication dates of primary studies by sex. The 1981-1984 period represents the bulk of the publications. The research was probably performed in the period of 1977-1980, when funding was easier to acquire. Only one study, in 1979, had a population of only males. Studies with all female populations were not plentiful until 1975; thereafter, the number of publications appear to peak and decline in a cyclical pattern. The data for 1986 are minimal since the data search had not been completed at the time of the report.

Table 6 shows the distribution of the five categories of factors by race/ethnicity and sex. Figure 13 shows the same distribution in percentages. The total for factor categories adds up to 945 because some of the 370 empirical studies looked at more than one type of factor. For example, 286 of the 370 empirical studies cited educational factors in SET career choice and success. Nearly as many cited personal factors. Cultural and career factors were studied in 190 and 145 empirical documents. Economic factors are mentioned in only 54 documents--a surprisingly low figure considering that the education necessary to most SET careers requires a substantial commitment of money, and of time (without wages). Perhaps sociological and psychological researchers find economic factors of lesser interest, or, of lesser complexity, hence demanding less research attention.

The large proportion of studies citing educational factors in comparison to career factors is probably related to the fact that, as noted above, most studies were conducted in educational settings.

Factors

In Figures 14 through 17, the distribution of variables in primary articles is shown in percentages for the cultural, educational, career, and personal factors. There were too few studies on economic factors to warrant an analysis of those variables. Of all primary articles dealing with cultural factors: 129 discuss barriers such as sex and race bias; 94 discuss role models (parents' educational level, careers), 85 discuss retention (family moral support), 58 discuss expectations (family expectations, cultural/social expectations), 23 discuss counseling, 7 recruitment, and 92 discuss other cultural variables. Totals may be larger than the number of documents because more than one factor may be mentioned in a document.

The category of educational factors contained the highest number of variables: 114 documents on counseling (academic, choice of career, or tutoring); 121 documents on barriers (for example, teacher qualifications, type of high school, sex bias, race bias); 180 documents on scores (SAT, grade point average,

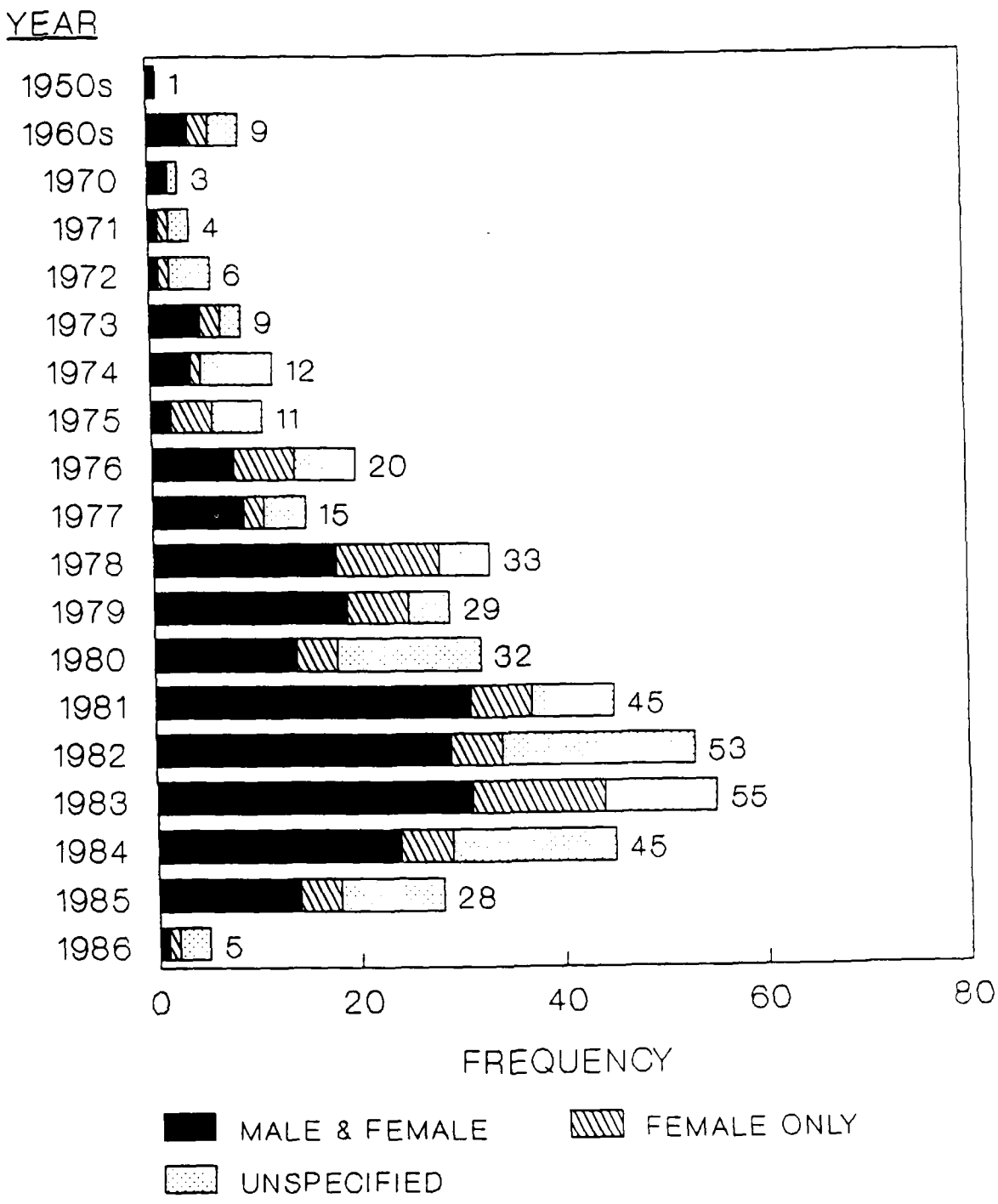


Figure 12. The Distribution of Primary Documents by Year of Publication and Sex of Population

TABLE 6

Distribution of Factors by Race/Ethnicity and Sex

ETHNIC/RACIAL GROUP BY GENDER		FACTORS				
		CULTURAL	EDUCATIONAL	CAREER	PERSONAL	ECONOMIC
American Indian	29	12	22	8	16	8
male/female	8	5	7	2	5	3
female only	1	0	1	0	0	1
unspecified	20	7	14	6	11	4
Anglo	47	27	36	21	35	5
male/female	25	17	20	13	22	2
female only	3	1	2	1	1	1
unspecified	19	9	14	7	12	2
Asian American	26	9	15	9	13	3
male/female	10	3	6	4	7	1
female only	1	0	1	0	0	1
unspecified	15	4	8	5	6	1
Black	66	33	50	28	44	15
male/female	35	21	30	16	29	7
female only	4	2	3	1	1	1
unspecified	27	10	17	11	14	7
Hispanic	56	30	44	19	39	12
male/female	20	12	17	9	16	4
female only	3	1	3	1	2	2
unspecified	33	17	24	9	21	6
Other	9	5	7	2	6	0
male/female	6	3	5	1	4	0
female only	0	0	0	0	0	0
unspecified	3	2	2	1	2	0
Mixed Minority	6	2	5	2	5	0
male/female	5	2	5	2	4	0
female only	0	0	0	0	0	0
unspecified	1	0	1	0	1	0
Unspecified	272	141	214	112	210	33
male/female	160	77	124	61	130	15
female only	58	36	53	32	46	8
unspecified	54	28	37	19	34	10
All Studies	370	190	296	145	270	54
male/female	203	103	162	78	162	23
female only	64	39	58	34	49	10
unspecified	103	48	66	33	59	21

Data derived from 370 empirical studies

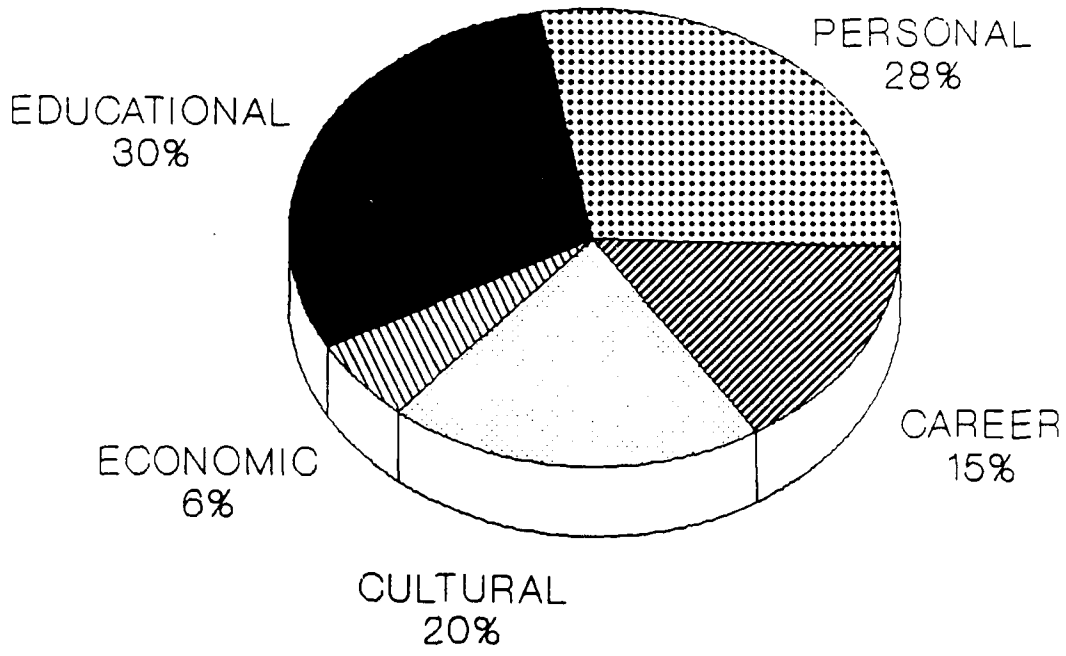


Figure 13. The Distribution of Empirical Studies by Factors

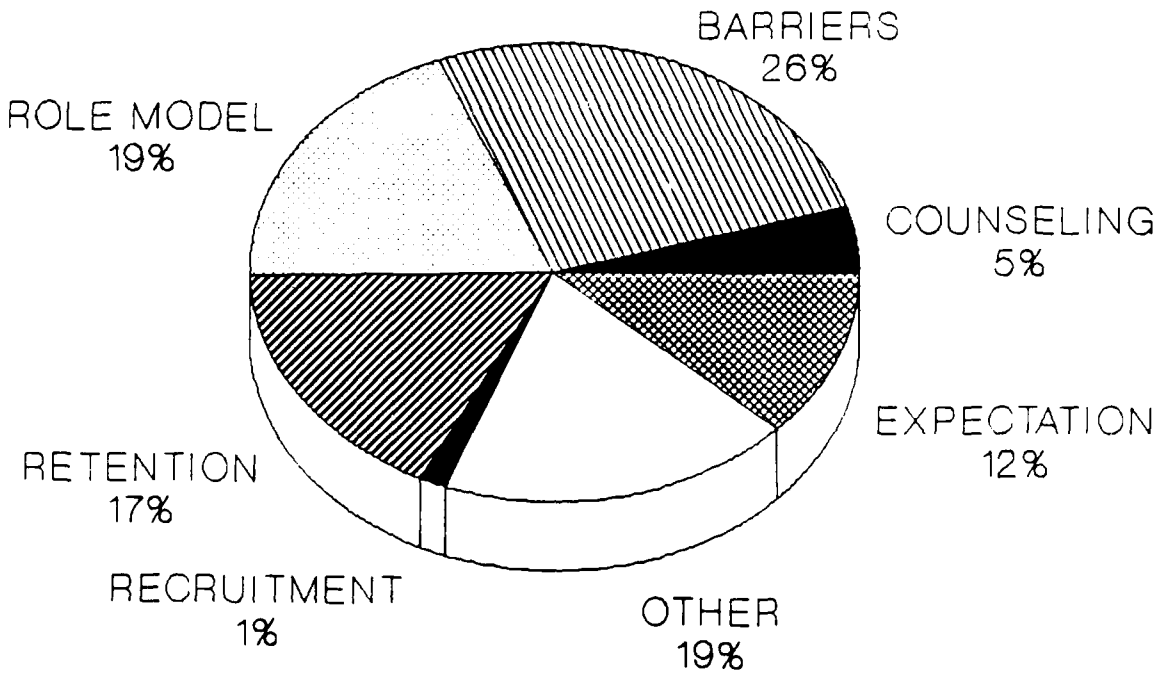


Figure 14. The Distribution of Cultural Factors by Categories

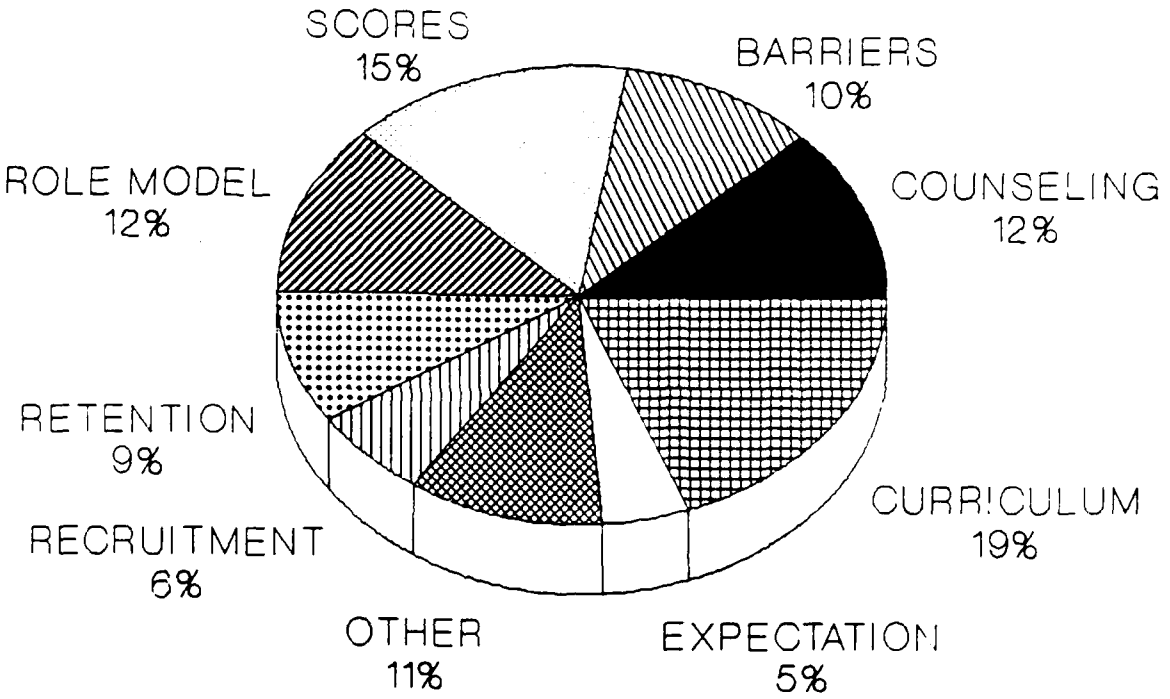


Figure 15. The Distribution of Educational Factors by Categories

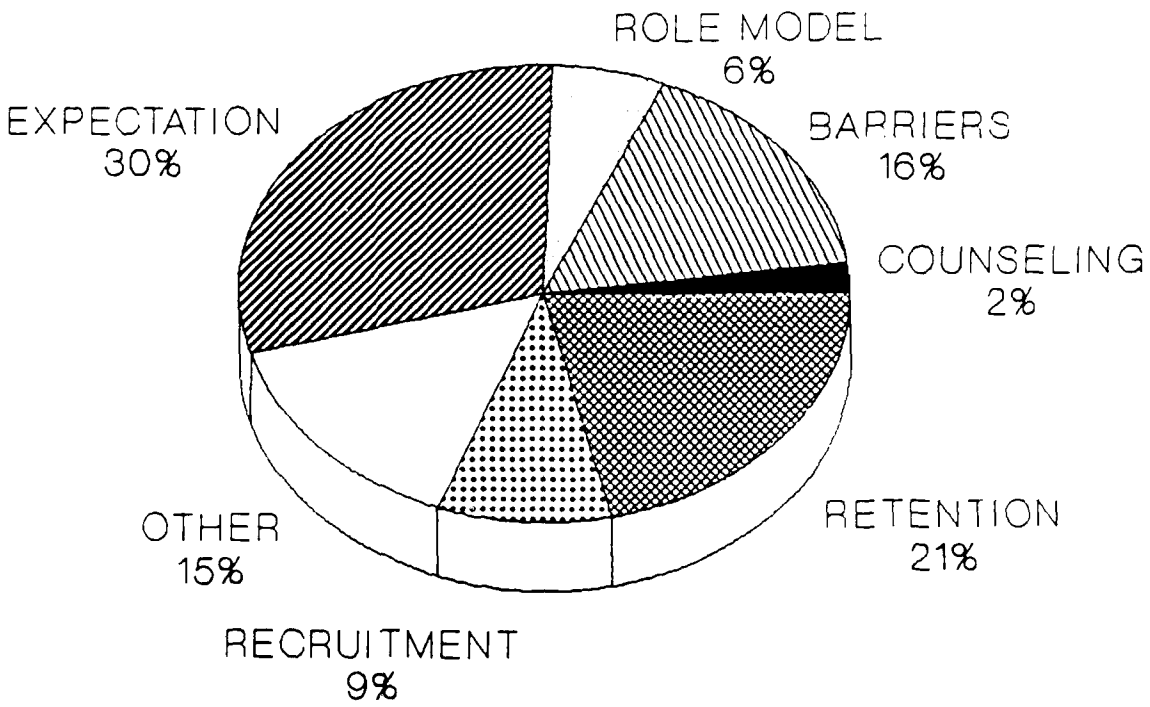


Figure 16. The Distribution of Career Factors by Categories

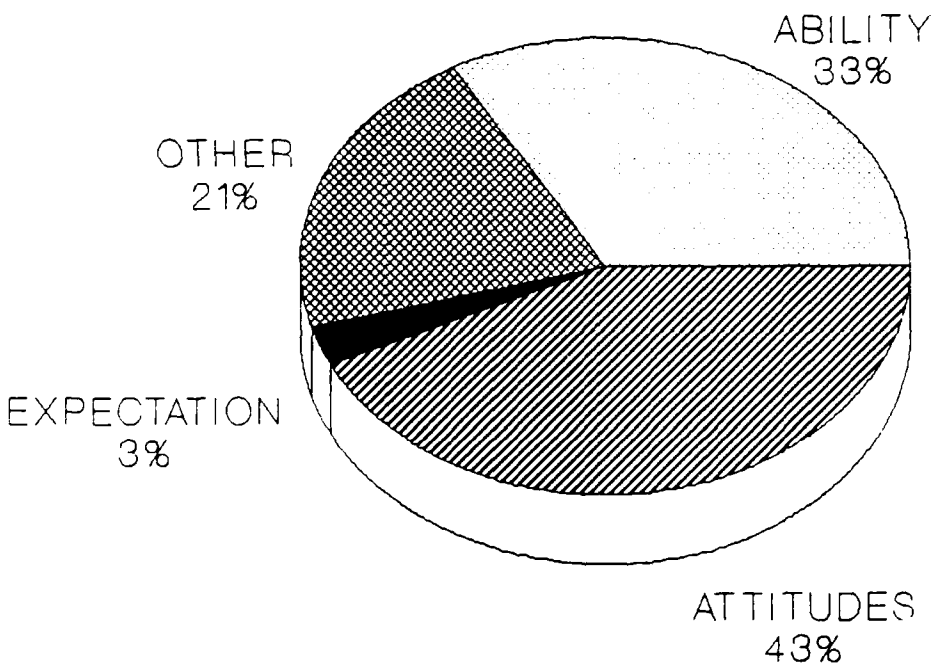


Figure 17. The Distribution of Personal Factors by Categories

etc.); 144 on role models such as teachers and visiting professionals; 112 on retention (including internships, peer support groups); 74 on recruitment (support from authorities, policies on women and minorities); 54 on educational expectations; 227 on curriculum (including special courses and extracurricular SET programs); and 124 documents on "other" variables which were not readily classifiable in the above categories.

The expectations variable is represented by the most studies (100 in Career Factors, totaling 29.9%, see Figure 17). Next, in number of articles for each variable, are retention, with 72 studies; barriers, with 55 documents; other variables, 50; recruitment, 31; role models, 20; and counseling, with 7 documents. Researchers are at least aware of the problem of barriers in the workplace to women and minority SET career success. Retention efforts require subjects that have entered SET programs; i.e., been recruited, and the research emphasis on SET career recruitment is inadequate.

Personal factors are broken down into variables in Figure 18. Attitudes, such as interest in SET, achievement motivation, and self-image, were studied in 245 primary documents. Ability, including aptitude, skills for stress management, and adaptability, was studied in 190 documents. Personal expectations were discussed or measured in only 16 studies.

Figure 18 shows the distribution of factors among the 64 documents on female populations for empirical studies. These studies on female populations represented close to 10% of the CASET data base. The disparity between the large number of studies on educational factors and the small number of studies on economic factors suggests that either money is not a problem for women or that researchers are remiss. The other factors, however--cultural, career, and personal--are fairly evenly represented, by about 100 documents each. The data on primary studies was very similar to that of the empirical studies.

Work on the question of the underrepresentation of American Indians, Blacks, Hispanics, and women seems to have reached a plateau in a number of areas: published lists or inventories of interventions and programs designed to encourage women and minorities in SET study and careers (Aldrich & Hall, 1980; Department of Education, 1984, Gordon et al., 1986; Malcom, 1984; NACME, Inc., 1984; National Science Board Commission on Precollege Education in Mathematics, Science, and Technology, 1983); workshops, conferences, and symposia with invited speakers giving presentations which are either overviews or original research; committees and organizations with membership from a wide range of organizations who convene periodically to give advice to yet other organizations and institutions; experts, Federal employees, and other spokespersons who represent Federal

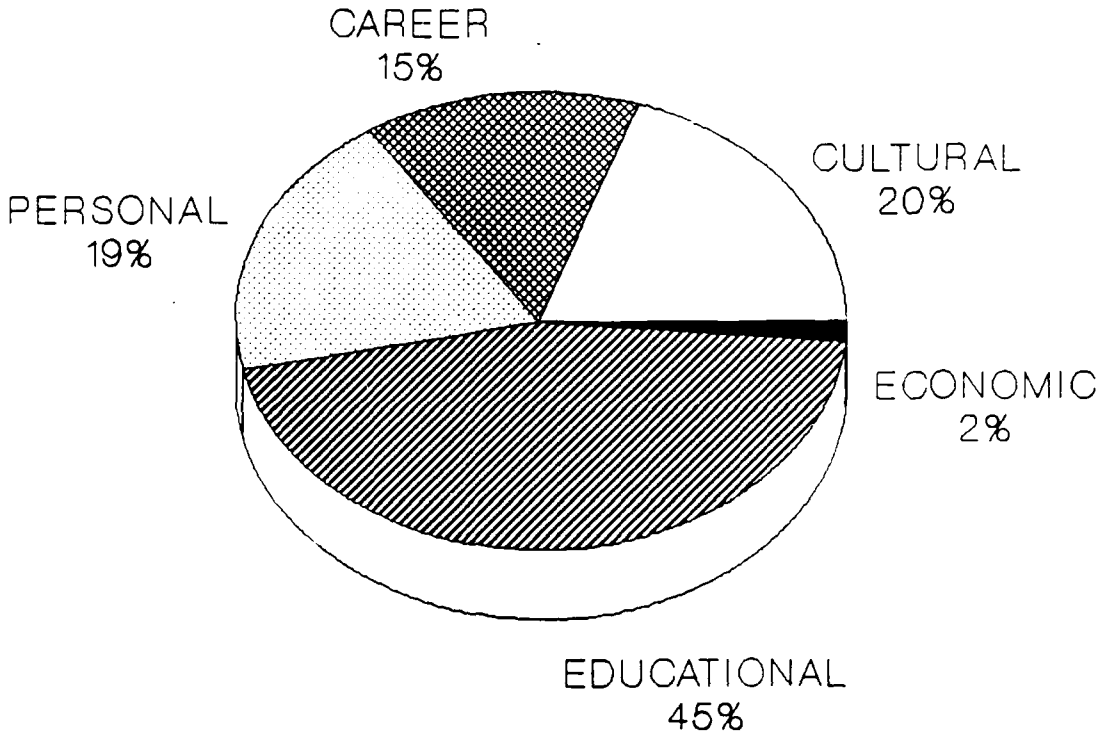


Figure 18. The Distribution of Factors on Empirical Studies of Women

agencies and are designated to speak out on the problem periodically; programs which have been running long enough to be more or less institutionalized with their own staff and annual reports and other publications such as those published by NACME and GEM. See Cooke (1984) and Adams (1986) for details on these programs.

Although there is much activity, there is little action leading to a coordinated effort which will result in a national clearinghouse representing all concerned groups and leading toward policy through a Congressional mandate. In summary, although much is being done, the effort is still fragmented among many players.

Although much is known about the quantity issues, very little is known about the quality issues. In other words, we know presently the numbers of minorities and women in SET careers, we know the projections for the future based on the birth rate of today, we know that there will be a demand for SETs based on the continuing technological thrust of our nation. But we know less about the qualitative reasons for entry into SET careers and decisions to either remain or to leave the SET pool. One of the very large issues is how to increase the quantity without lowering the quality of SETs. If quantity and quality are mutually exclusive, there may not be large numbers of people with the aptitude and interest to become competent SETs. The answer to this supposition can only be found by increasing the numbers of minorities and women who are provided with access, and the support systems to remain in the field, long enough to become credentialed.

The number of students receiving economic aid from the Federal government has declined in the past few years. Yet, the high school and beyond (HS&B) longitudinal study found that college students stay in school at higher rates when they receive grants or scholarships. This may be especially important in majors such as engineering, where the homework is overwhelming and keeping a part-time job is difficult in the face of academic requirements.

The shortage of SETs has implications for our nation's immigration and naturalization policy. Since many of the foreign nationals would remain and work in the United States after receiving their degrees, it would be possible to relax naturalization requirements and, in effect, have many more SETs than we now have. However, this policy change would not materially solve the DOD potential SET human resources shortage because of security requirements.

As more minority members go into careers other than teaching, we may be facing an education system where half or more of the students are minority and the teachers increasingly less

likely to be members of minority groups. This situation poses problems for role-models and can lead to cultural conflict. As there continues to be a shortage of math and science teachers, even as there is a shortage of math and science workers in industry and government and higher education, the prospect of recycling workers into these careers after retirement or as a career change becomes even more important. At issue within the teaching community itself is the question of higher salaries for math and science teachers. This issue is a divisive one, yet retired and other persons coming from business would be accustomed to receiving salaries than are normally paid to teachers in a public school system. Additionally, the recycled persons from other careers have not grown up in, or become tenured, so to speak, in the public education system. These people may, in fact, like to teach science and/or mathematics, but may not be interested in other aspects of teaching as a profession. They might, in fact, only want to teach part-time, and not be interested in administrative duties or other aspects of student care/interaction.

To this end, it might be profitable to consider having math and science teachers be "adjunct teachers" or "associate teachers," or some other designation indicating that they teach only a SET subject and are not involved with the full-time teaching and administrative responsibilities of a "professional" teacher. Addressing the question of what the issues are, it should be noted that not everyone is concerned about the underrepresentation of minorities and women in these careers. For example, the President of the National Academy of Engineering (NAE), in his report to the National Academy of Engineering (NAE 21st Annual Meeting in 1985) did not address this issue at all. In speaking of "new directions for engineering," Mr. Robert M. White referred to "an unprecedented surge of interest in engineering research and education" (NAE, 1985). It appears that priorities for engineering research for the NAE do not include efforts to expand the engineering pool by encouraging women and minorities to engage in engineering as a career.

Mathematics is the quantitative field where the most attention to women has been centered. Efforts seem to be bearing fruit there. Although mathematics is still seen as the "critical filter" (Sells, 1976 & 1980), it is not clear why women engage in mathematics study at fairly high rates (although not proportional to their percentage of the population) yet do not go into careers which require mathematical training, such as engineering, at the same rate as males.

The literature review brought out a research question which will be of continuing importance in America--the question of why the (new) Americans of Asian heritage do better in the quantitative sciences than not only America's underrepresented minorities and women, but also than Anglo males (Butterfield,

1986). The average mathematics Scholastic Aptitude Test (SAT) score for Asians is 520 points and only 490 for Anglos.

Akin to the issue of immigrant students is the issue of foreign nationals studying and working in America. Many of the foreign nationals who come to the United States to study quantitatively based subjects are from South and East Asia as well as India, Bangladesh, and the Arab countries. In the 1970s, many more Arabs were studying in the United States than at present because of a large group from Iran. In the absence of qualified American national faculty, many colleges and universities are hiring foreign nationals to teach, particularly in the science and engineering fields. Foreign students are also serving as teaching assistants and research assistants. Anecdotal data indicate that American women students may be at a disadvantage in those classes where faculty come from countries where women have a subservient role and are expected to "keep their place."

The Office of Technology Assessment (OTA) Technical Memorandum (1985) pointed out two barriers to participation of women in quantitative careers: 1) their own career expectations were hampered by sex stereotyping (i.e., certain work was masculine, and certain work was feminine); and 2) women received less favorable treatment in the work force, such as lower pay and less comfortable atmosphere and attitudes in the workplace.

One could almost say that "there is no such thing as a bad intervention" because many reports and researchers agree that interventions are useful and do work (Malcom, 1984; OTA, 1985). But the slow rate of increase of minority and female participation in SET careers suggests that more solutions still need to be developed.

It may be that we, as a nation, are attempting to produce educational solutions to what are, in fact, cultural problems or issues. Values are a reflection of culture, and each racial group and each ethnic group has its own culture. One of the reasons given frequently for the academic success of Asian Americans is that their values include and place a high priority upon education. By implication this means that American Indians, Anglos, Blacks, and Hispanics do not. Certainly, the dropout rate in high school is greater for minority groups (see Table 7), which would seem to support the notion of the lesser value these groups place on education. The difficulty in measuring public school dropout rates is discussed in "The Condition of Education" published by the Government Printing Office (Stern, 1986). If in fact values are the problem, then the solution is to look within the culture for factors which can be interrelated or interwoven with education. Granted that the low socioeconomic status of many of these minority groups places them in schools which have

TABLE 7

Dropout rates for 1980 high school sophomores by sex and selected background characteristics

Background characteristic	Percent dropout rate		
	Total	Male	Female
All students	13 6	14 7	12 6
Race/ethnicity			
American Indian and Alaskan natives	29 2	27 2	31 8
Hispanic	18 0	18 1	18 0
Black	17 0	20 3	14 1
White	12 2	13 0	11 5
Asian American	3 1	3 5	2 7
Socioeconomic status			
High	5 2	7 0	3 2
Middle	9 0	9 6	8 3
Low	17 4	17 8	17 1
Unknown	31 6	32 3	30 9
Community type			
Urban	18 9	20 8	17 0
Suburban	11 8	12 5	11 0
Rural	12 8	13 6	12 0
Geographic region			
Northeast	11 3	13 4	9 0
North Central	12 0	12 2	11 7
South	15 2	16 4	14 0
West	16 6	17 0	16 3
School type			
Public	14 5	15 5	13 6
Catholic	2 3	3 2	1 6
Other private	—	—	—
High school program			
Academic	4 0	4 5	3 6
General	12 9	12 7	13 0
Vocational/technical	15 1	16 9	13 2

—Estimates not presented because of small sample size and high nonresponse in the base-year sample.

SOURCE: U.S Department of Education, National Center for Education Statistics (1983), *High School Dropouts: Descriptive Information from High School and Beyond*, NCES 83-221b.

fewer computers, fewer math courses, fewer science courses, and in general a less rich educational environment than the middle-class schools where middle class children of all races and ethnicities go. Still, there are children who go to those resource-poorer schools and who do achieve and go on to colleges and universities, where they do well. Motivation may lie within a person's values. Motivation, which is frequently first developed in the home, can be enhanced or diminished by the cultural values of the family. Cultural values and the educational system need to work together and cooperate for the economic well being of our nation and the people who live in it.

For a summary discussion of both structural and developmental theories of Careers, see pp 11-34 in "Using Labor Market Information in Career Exploration and Decision Making: A Resource Guide (by The National Occupational Information Coordinating Committee, Garrett Park, MD: Garrett Park Press, 1986).

Several of the theories recognize the impact of culture on vocational decision making. Sex and race/ethnicity are cited as socioeconomic variables; however, none of the theories reviewed relate their assertions to the population subgroups of minorities and women in any meaningful way.

Very little comparison of success of interventions vis-a-vis racial and ethnic groups, has been attempted. The success or failure of the intervention has not been attributed to the personal characteristics of the subgroup member participating. Therefore, it is unknown whether or not an intervention could be more successful if it were more culturally appropriate, nor is it known if the lack of persistence on the part of minorities and women in SET study and careers could be counteracted by interventions which were more gender and culturally specific.

Very frequently, the research consisted of Anglo researchers who collect data and then analyze and manipulate those data with models and statistics. Very few interventions contain an evaluation component, and very few interventions are ever followed up.

If we do not intend to increase the number of SETs through lowering of immigration and naturalization requirements and standards, then we need to increase programs designed to see that American nationals continue their education with the aim of achieving technological literacy and competency. At the present time there are approximately 1 million students studying away from their home nations. In other words, there are about 1 million foreign national students in the world, including those American citizens who are studying outside the United States. About one third of the 1 million foreign students are studying in America.

This number is an indication of the success of a foreign policy which was developed by the United States after World War II. As part of the foreign policy of the United States, citizens of other countries, including those who had "lost the war", were encouraged to come to the United States and study to gain expertise in rebuilding their countries. Thus, technical and quantitatively based study was particularly encouraged. Now, 41 years later, this foreign policy has turned into an educational policy. In place of the few, or trickle, of foreign students studying and learning American technology and know-how, America is now host to a flood of foreign nationals who are not only learning our technological system and our "can-do" philosophy, but who are going home and applying it with such vigor and expertise that America is now a debtor nation.

The trade deficit is not a result of America's doing badly in technological competition, but rather a result of too many other nations doing too well. Foreign students have improved their career opportunities whether they return to their native country or whether they eventually succeed in staying in America on an extended student visa, an extended student temporary visa, a worker's permanent visa, or eventually as a naturalized citizen. Industries frequently are quite happy to hire foreign nationals. Frequently, the salaries are lower than those of American citizens; and in order to remain in the United States, the foreigners are "model employees." The same thing is true of foreign faculty, foreign teaching assistants (TAs), and foreign research assistants (RAs). They are happy to do research for their tenured professors and frequently are almost as knowledgeable as the professor, since many of the students are the best and the brightest of the educational systems of their home nations.

Women live in the world which technology helps to shape, and their contribution is needed, not only for the productivity their human resources provide, but also for their unique perspective. Otherwise, science and technology will continue to be a male domain. Serious as that was in the past, since women were not in the work force outside the home in large numbers, it was not critical. Now, however, when approximately half the work force is female, and more and more women are working outside the home, there is a crucial need for science and technology to be a collaborative effort between women and men.

Because technical and quantitative occupations are nontraditional for women, a state of occupational segregation has come into existence. Women are clustered in the careers of teaching, nursing, secretarial, clerical, librarianship, social sciences, and psychology. In some areas which were nontraditional in the past, such as the legal and medical professions, they are making dramatic increases. But in the

natural and physical sciences, in engineering, in computer science, they are still underrepresented.

Based on the CASET findings from the literature search, minorities and women follow "pathways" and "roadmaps" and deviate from their course on the way to entering a SET career. Because of the low socioeconomic condition of many minority students, they often have to make stops along the way and in essence "drop out" temporarily; their journey is not the smooth one of a "pipeline." One example cited in the literature (Graduating Engineer, 1985) is that of Tessa Archuleta, who at 32 years of age changed careers from Financial Aid Counselor to civil engineering student. Ms. Archuleta had "stopouts" during her academic career to have a child, for example.

Because minorities and women follow roadmaps instead of pipelines, they often suffer in academic competition for places in SET fields (Hall & Sandler, 1982; Lantz et al., 1982).

A cause and an effect of the underrepresentation are the barriers to their full participation, and even those who do participate are rarely in a position of power or policy-making. The barriers are cultural, educational, economic, personal, and career/occupational, and solutions need to attack the problem on all these fronts.

Lack of competence or ability on the part of women is not a barrier to their participation in SET careers. Why, then, are the SET fields the domain of men? The answers lie in tradition, in culture, and in the events such as the World War II GI Bill. A cycle of powerlessness, where technology and decision-making is concerned, has been the inheritance of women. Men have chosen men to replace them in their jobs, and thus males have reproduced themselves in the world of science and technology. They choose the issues, frame the paradigms, prioritize the problems, and declare what is a solution.

Specifically, Rand (1976) analyzed the factors that affect labor force activities of women and reported the difficulties often faced by women in pursuing discontinuous work lives and the problems of managing multiple roles. First, for example, the broad outlines that characterize the work life of women include career discontinuity, a relatively high incidence of part-time employment, and concentration into "women's occupations"--all of which create difficulties in terms of lifetime productivity and earnings. Second, although women may increasingly adopt less discontinuous work lives in the future, the problems of role conflict and role sequences will remain and perhaps increase.

Rand's report reinforces the growing supposition among minorities and women that educational institutions very rarely survey target populations in order to determine actual needs, but

rather develop educational programs based on the interests of the academic initiators or on cultural stereotypes. CASET's research confirms that very few studies are culturally and racially or ethnically specific.

CONCLUSIONS

Because of the great extent of the scientific literature relevant to the participation of women and minorities in SET careers, the 682 documents in the CASET data base are only representative of that literature. The incompleteness of the data base at this time allows only preliminary conclusions to be drawn. In Phase II, the data base will be expanded and updated, with approximately a doubling of the documents. Conclusions drawn at the close of Phase II will reflect a quantitative synthesis (meta-analysis) of the empirical findings.

The literature search reveals that problems still exist in America which hinder the utilization of human resources, including especially the subgroups of underrepresented minorities and women in SET study and careers. Believing that change is possible, all sectors (government, industry, and academia) must work together to add women and minorities in greater numbers to the SET pool.

Legal blocks to proportional representation have been legislatively removed. The next blocks to go will be the social and cultural barriers, including the persistence of stereotypical sex roles. The sociocultural barriers are the most persistent, because they are the most pervasive. They are the personal, or idiopathic barriers, such as an individual's mind-set, an individual's habit of stereotyping another individual, self-perceptions which limit one's belief in one's abilities and competence. Also included in sociocultural barriers are beliefs by either sex in male dominance and female subservience, or in male superiority and female incompetency. Changing cultural attitudes have been brought about by the Civil Rights Movement, the Women's Movement, and the increase of women in the American work force.

The problem in America today is one of human resources, not of equal opportunity or women's liberation. The barriers are institutionalized in the culture in the form of ethnic and racial stereotypes and sex roles stereotypes. These are particularly prevalent in the fields of physical and natural sciences and engineering, which have always been dominated by Anglo males. Stereotyping is not only a barrier to occupational parity, but it is a barrier to full participation in economic and political life. Access has been provided by the Civil Rights Movement of the 1960's and the Women's Movement of the 1970's, yet barriers still exist. CASET concludes that the racism and sexism of the

past have been replaced by the stereotyping of today. The occupational segregation in America's workplaces in itself results in a differential distribution of the benefits of the information age we are entering. Access to knowledge and power is impossible if there is no access to the technology which creates it. Occupational segregation prevents women and minorities from fully participating in the life of the United States. Those who are not scientifically and technically literate will in the future be condemned to live lives of denial and deprivation through poverty of information and poverty of job opportunity--as well as actual economic poverty.

Because of the already low socioeconomic status of minorities and women relative to Anglo males, failure to exert all pressures to bring these groups into the mainstream job market through technical competence could result in the largest "underclass" of technical incompetents in the history of our nation.

The DOD recognized early that minorities and women can make a vital contribution to military preparedness and economic security. To have a voice in the future of technological development and the paths such development will take, steps must be taken now to ensure that occupational segregation is broken down, enabling all portions of the U.S. population to be represented in SET study and careers.

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APPENDIX A
STUDENT INTERVIEW

This unstructured in-depth interview was conducted by the PI and lasted about 2 hours. The subject, Kim (a pseudonym), was in her second semester of a PhD program at a Texas public university. She had a B.S. in Electrical Engineering from a historically Black state institution in the same region of the United States as her present graduate school.

She was one of three children and the only girl. Only one of her brothers went to college, but he dropped out. Her father's educational level was a Master's degree, and he was a mathematics teacher in a high school. Her mother worked in a special education school, but it was not clear whether the mother was a teacher. Kim had a cousin who was an engineer.

Following the life cycle approach, Kim stated that her studying engineering came about because a high school counselor suggested it to her. Kim's ambition had been to be a high school math teacher like her father. When she expressed this ambition to her counselor, the counselor suggested that because she was good in math and liked it, she should consider becoming an engineer. The counselor pointed out that the career opportunities were in engineering and that she would make more money.

Kim had taken advantage of several programs in the summers during high school and college. Her high school was integrated, but a Black counselor counseled the Black students, and a White counselor counseled the White students. "No one ever asked me did I want to go to a White university," Kim said. Between the junior and senior years, the counselor enrolled Kim in a pre-engineering summer program at the state university she eventually attended. The program lasted six weeks. Program mechanisms included living on campus, seminars, field trips, and talks by professionals in engineering.

She had spent two summers working at a government lab and two summers working for IBM in a Texas city. When queried as to the relative merits, Kim replied that she much preferred working in the government lab. She learned more and she also preferred the "slower pace" and the more informal dress code. Regarding the IBM work experience, Kim said she realized that IBM was a business, and people had their work to perform in order to meet deadlines, but she felt that because of lack of supervision and time spent with her, she learned much less than she did in her summer work at the government labs.

The graduate school in Texas had sent a recruiter to the neighboring state's university and "actually, I stumbled upon a recruiter from _____ ____...like after my sophomore year, I told

him I was interested in graduate school and what I was interested in, and he said that they were looking for some minority students." So, basically, they just started sending me information until it got close to time for me to register.

Kim was also accepted by the Massachusetts Institute of Technology (MIT), Purdue University, and The University of Illinois. She chose her present school because it was closer to her home than any of the others. Kim has a Fellowship and is also a Teaching Assistant. She asked for the latter, in addition to her Fellowship, because she wanted to buy a car.

Although she decided to go on to graduate school, Kim had seven or eight job offers, including 3 or 4 IBM locations, Bell Laboratories, AT&T Information Systems, and the Harris Corporation, at salaries ranging between $27,000 and $31,000.

Kim felt that she was doing well in school. She found the courses hard but not impossible. When asked what advice she would give someone considering the same major at the same university, she said that she would advise them to go to graduate school in the same place they took their undergraduate work. Her reasons were that even though courses may have the same names, in fact the content is different, and insome of the courses she was taking, she felt that she really had not had precisely the correct undergraduate course work for moving on into graduate work in those areas. She even went so far as to say she should have come and taken some courses as an undergraduate at this university, even though she had a degree from her previous university; that having some undergraduate courses there and being better prepared for graduate school would have been of benefit to her.

When asked, Kim said there were two other Black students (one male and one female) starting as freshman with her, but they are in different engineering specialties, so they have no classes together. In one class of 25, Kim is the only female and the only Black. In fact, she is the only Black in all her classes.

The interviewer asked, "Does anybody talk to you, do you share?" Kim replied, "Actually, I feel pretty alienated right now. Maybe as time goes on, I'll find some people, but right now...it's like, fend for yourself 'cause there's no one there."

The PI asked, "So if you had a problem or wanted someone to study with, you would not feel comfortable going to one of the White group and asking 'Can I study with you' or 'Would you share your notes?'"?

Kim's answer was, "Well, sometimes, I ask people questions and they answer me, but, you know, it's like you don't always want to have to ask them for something, you know you want to feel

like you're giving and they're giving, so that's kinda like an on-going thing." But Kim said there was none of that.

The interviewer asked her how she would rate the quality of her life; i.e., her day to day pleasure in life, interest in life, enjoyment of life, apart from her academic work in this city at this institution, on a scale of 1 to 10. Kim answered "About a 3 or a 4." This low level of quality of life judgement was not apparent from her answers to the other questions or from her relating experiences she had had. She was not angry, or bitter, or depressed, or complaining. She was a very self-possessed, self-reliant person. She did say that her self-confidence had been damaged somewhat, since she had been at this school. When she arrived, she felt that she was smart, that she was capable, that she could "make it." And although she felt she could still make it, she said her self-confidence had deteriorated.

When asked what one thing she would change if she could about the whole experience, including academic items, Kim said that she would like to have "a professor I could trust." This response was undoubtedly an outcome of an unfortunate cross-cultural communication gap which she had with one of her professors. All of her professors are Anglo males. The circumstances surrounding the misunderstanding seemed to indicate clearly a cross-cultural communication problem. She had class two times a week with a professor who had agreed to serve as her advisor in a project she needed for her graduate work, possibly leading into being her main advisor and the chairman of her PhD committee. She had arrangements with him during the first month of her first semester at the institutions, and she had seen him twice a week thereafter. About three weeks before the end of the semester, she went in to see him to discuss the next semester's project which she would be doing under his guidance for a three hour course. At that time he told her that he would be unable to serve as her advisor for this 3-hour guided instruction course, as he had several PhD students who were not graduating after all, and his time was fully taken. This meant that, in effect, she was losing a semester's work, because she could not now find another professor to be her advisor for a similar project. She was very upset about this, to the extent of calling her parents and even thinking of withdrawing from the university.

A further problem was that she had no idea what to do. Even though this university says it has a minority engineering program, and there is a chapter of Women in Engineering there, and supposedly a support system, she said she did not know where to go or whom to ask for advice. Her parents advised her that she might have the same problem anywhere she went, and that if at all possible, she would be better off to stay there, even though she would have to stay a semester longer now. At length, she finally remembered that there was an older man (she never said of

what race or ethnicity this man was) in the class who worked full-time as an engineer, and was respected by all the professors because of his knowledge and ability. She decided to ask him what to do. He discussed the problem with her, suggested another professor also in her field, who might have some time, and how to approach him and what to say to him in order to get him to be her advisor for a guided course the next semester.

Kim followed her fellow student's advice and arrived at a provisional agreement with the new professor. He would be her advisor on a project for this next semester. If that worked out, then he would seriously consider, and probably would, take her on as a graduate student and agree to be the chairman of her PhD committee. So, Kim's problem was solved, at least temporarily, but from an objective point of view, two conclusions can be drawn; One, the support system which the institution thinks it has is, in fact, either not what is needed or is not accessible to this Black female engineering student; secondly, the misunderstanding between Kim and the first professor may in fact have been a breakdown in communication. Her feeling was that how could she be seeing him twice a week, and he didn't tell her that he could no longer "mentor" her until she went in and talked to him about it. His position probably was that since she had not been in all semester to discuss it, she might no longer be interested in doing the project. The point is that each came from a different culture, a White Anglo older male, and a young Black female. Although they thought they were communicating, they were not; therefore, each could have benefitted from learning communication styles of other race or ethnic groups.

The PI asked Kim how she felt about her performance academically. Kim replied, "I found out that I wasn't prepared and it wasn't the courses I took; it's just that I didn't prepare myself to go to graduate school." Kim didn't feel the undergraduate courses she took were up to par. She said, "I feel like somebody is beating me down and I don't have the same confidence level that I had when I came here. I had a lot, and I still feel that I can make it, but it's just been rough." She added later, "The only reason I'm still here is that I don't want to let down a lot of people...people from my school have a lot of faith in me and my family...that's the only reason I'm here."

One dialogue went this way:

Kim: There's a graduate opportunity...like a minority thing. It's great to recruit us, but to keep us here and let us finish, they don't really have anything. Like they never call you and say "how's it going?" There's really nothing personal about it except they send you your check every month; that's about it. They need people to do something like that because they know who the minority students are in all the areas.

PI: What office?

Kim: This is the VP for graduate studies, the check comes from there - specific minority funds.

PI: In other words, they should be doing something.

Kim: We had this long talk with the dean of the school, we were just voicing our concerns to him.

PI: What's his name?

Kim: Don't remember now, he's a white male and he was listening.

PI: When you say we, was this the engineering group?

Kim: No, there's a little pool of Black graduate students throughout this university. They just informally got together. There's an organization but it's not really structured, 5 to 10 people. We're trying to tell him how it is in your department like you bring us here and that's it. We don't want any special attention as such, but there has to be something that they can do. Your goal is to get more minorities, but if it's not the goal of the instructors in the department, then forget it.

APPENDIX B
RELEVANT TOPICS

SUBJECT	ESTIMATED NUMBER OF APPROPRIATE JOURNALS
Aeronautics and Space Flight	138
Anthropology	50
Architecture	56
Biology	59
Business and Economics	170
Chemistry	80
Computers	95
Education	273
Electricity and Electrical Engineering	118
Engineering	161
Environmental Studies	126
Ethnic Interests	107
History	102
Industrial Health and Safety	50
Mathematics	63
Metallurgy	53
Military	121
Physics	70
Public Administration	93
Sciences: Comprehensive Works	100
Social Sciences: Comprehensive Works	73
Sociology	99
Technology: Comprehensive Works	65

Women's Interest		111
	Total	2433

APPENDIX C
DATA FILES SEARCHED

ABI/Inform

Aerospace Data base

AIM/ARM (Abstracts of Instructional and Research Materials in Vocational and Technical Education

America: History and Life

American Statistics Index

AV Online

CA Search

Career Placement Registry

Catalyst Resources for Women

Cendata

Compendex

Comprehensive Dissertation Index

Conference Papers Index

Current Index to Journals in Education (CIJE)

Defense Technical Information Center (DTIC)

Donnelley Demographics

Federal Research in Progress

FIND/SVP Reports and Studies Index

Ford Foundation Archives

GPO Monthly Catalog

Harvard Business Review

Historical Abstracts

Industry Data Sources

Information Science Abstracts

INSPEC (Information Services for the Physics and Engineering Communities)

Magazine Index

Management Contents

Mathfile

National Newspaper Index

National Technical Information Service Bibliographical Data Base (NTIS)

PsychALERT

Psychological Abstracts Information Service

Resources in Education (RIE)

Scisearch

Social Scisearch

Sociological Abstracts

SPIN (Searchable Physics Information Notices)

SSIE (Smithsonian Science Information Exchange)

University Microfilm International (UMI)

APPENDIX D
CRITERIA FOR INCLUSION IN CASET DATA BASE

Categories A through D include the following:

- o Membership in subgroup of American Indian, Asian American, Black, Hispanic, or women.
- o United States of American citizenship.
- o Published document, including bibliographies, presented papers, and government reports.

Additional criteria for each specific category must be:

A. Highest Criteria
   1. About a SET subject
   2. About a ninth grade or above, postsecondary education, vocational training, or employment.

B. Second Highest Criteria
   1. Not about specific academic majors or occupation, but is concerned with information or data about education, training, and jobs.
   2. About a ninth grade or above, postsecondary education, vocational training, or employment.

C. Third Highest Criteria
   1. About majors or occupations which are tangential to SET, such as the life sciences (medicine, biology, nutrition, paramedical training, dentistry); geography, meteorologist; heat transfer technician; television; and radio repair person.
   2. About a ninth grade or above, postsecondary education, vocational training, or employment.

D. Fourth Highest Criteria
   1. About majors, courses of study, or occupations which are not SET or tangential to SET. Could be about subjects such as the social and behavioral sciences, law, business, English, foreign languages, and the non-SET trades.
   2. About a ninth grade or above, postsecondary education, vocational training, or employment.

APPENDIX E
CODING SHEET

I. A. ACCESSION NUMBER:_____

B. DATABASE/FILE:_____ DATE OF RETRIEVAL:_____

II. AUTHOR (Personal):_____

(Organizational):_____

_____

_____

III. TITLE:_____

_____

_____

IV. SOURCE:_____

Volume/Issue:_____Page:_____Year:_____

Report No.:_____Contract Grant No.:_____

Sponsoring Organization(s):_____

_____

_____

V. DOCUMENT TYPE:

1. Book
2. Book Chapter
3. Journal
4. Government Report
5. Industry Report
6. Dissertation
7. Unpublished Manuscript
8. Conference Paper
9. Bibliography
10. Audio-Visual
11. Instructional Materials
12. Manual or Handbook
13. College Report
14. Other, specify_____

(Coding Sheet)

VI. AVAILABILITY:_____

VII. GOAL AND FOCUS:

1. Empirical Study (Including Intervention Project Reports and Surveys)
2. Research Review
3. Theoretical Review
4. Position Paper
5. Anecdotal
6. Case Study
7. Evaluation Report
8. Other, specify_____

_____

VIII. SETTINGS OF RESEARCH:

A. TYPE OF ORGANIZATION:

1. Educational
2. Industrial
3. Governmental
4. Other, specify_____

_____

B. LOCATION: City_____State_____Not Specified____

Other, specify_____

C. IF EDUCATIONAL, NAME OF INSTITUTION:_____

1. Type of Institution: Public____Private____Proprietary___

Other, specify_____

2. Type of Degree given: HS Diploma___AS___BS___MS___PhD___

Certificate_____Other_____Not Specified___

3. Student Body: Coed_____F Only_____M Only_____

4. Religious Affiliation: Yes___No___Denomination_____

5. Technical/Vocational Institute: Yes__No__Not Specified__

(Coding Sheet)

6. Size of Undergraduate Population:

_____ < 1000 _____ 1000-10,000 _____ > 10,000

D. IF INDUSTRIAL, NAME:_____

Other, specify_____

1. Type of Industry (use SIC Code)_____

2. Size of organization and number of personnel_____

E. IF GOVERNMENTAL, NAME:_____

Other, specify_____

Civilian_____Military_____Laboratory_____

IX. FUNDING OF RESEARCH

Public____Corporate____Non-Profit____Other____Not Specified____

X. EVALUATION COMPONENT: Yes_____No_____Internal_____External_____

XI. COST COMPONENT: Yes____No____

1. Cost of the Project/Intervention/Program_____Unit Cost_____

2. Cost of the Evaluation_____Unit Cost_____

3. Cost of the Study_____Unit Cost_____

4. Other, please specify_____

XII. TYPE OF STUDY:

Primary_____ Secondary_____

(Coding Sheet)

NOTE: If coding secondary articles, just place checks.

If coding primary articles, enter numbers (if present) or else, place checks.

XIII. POPULATION CHARACTERISTICS

	Total	Male	Female
A. American Indian	_____	_____	_____
B. Anglo	_____	_____	_____
C. Asian American	_____	_____	_____
D. Black	_____	_____	_____
E. Hispanic	_____	_____	_____
F. Mixed Minority	_____	_____	_____
G. Mixed Minority & Other	_____	_____	_____
H. Other (specify)	_____		
And code	_____	_____	_____

NOTE: For the balance of the coding sheet:

If the article is primary, enter checks under the appropriate columns.

If the article is secondary, circle the capital letters which represent factors discussed.

XIV. CULTURAL FACTORS

	Mentioned Only:	Unfavorable:	Favorable:	Intervention:
A. COUNSELING/GUIDANCE				
1. Consult father	_____	_____	_____	_____
2. Consult mother	_____	_____	_____	_____
B. EXPECTATIONS				
1. Family expectations	_____	_____	_____	_____

(Coding Sheet)

	Mentioned Only:	Unfavorable:	Favorable:	Intervention:
C. ROLE MODEL				
1. Mother in related career	_____	_____	_____	_____
2. Father in related career	_____	_____	_____	_____
3. Mother's educational level	_____	_____	_____	_____
4. Father's educational level	_____	_____	_____	_____
D. RETENTION				
1. Family moral support	_____	_____	_____	_____
E. RECRUITMENT				

	Mentioned Only:	Yes:	No:	Intervention:
F. BARRIERS				
1. Differences perceived in status of SET careers	_____	_____	_____	_____
2. Sex bias	_____	_____	_____	_____
3. Race bias	_____	_____	_____	_____

XV. EDUCATIONAL FACTORS

	Mentioned Only:	Unfavorable:	Favorable:	Intervention:
A. COUNSELING				
1. Academic counseling	_____	_____	_____	_____
2. Career counseling matching individuals with majors	_____	_____	_____	_____
3. Academic tutoring	_____	_____	_____	_____

(Coding Sheet)

	Mentioned Only:	Unfavorable:	Favorable:	Intervention:
B. EXPECTATIONS				
C. ROLE MODEL				
1. Teacher, counselor, employer, professional role models	_____	_____	_____	_____
D. RETENTION				
1. Support from authorities	_____	_____	_____	_____
2. Internships and work study programs	_____	_____	_____	_____
3. Peer support groups	_____	_____	_____	_____
E. RECRUITMENT				
1. Policies on women and minorities	_____	_____	_____	_____
2. Support from authorities	_____	_____	_____	_____

F. BARRIERS	Mentioned Only:	Yes:	No:	Intervention:
1. Type of high school	_____	_____	_____	_____
2. Teacher qualifications	_____	_____	_____	_____
3. Sex bias	_____	_____	_____	_____
4. Race bias	_____	_____	_____	_____
5. Instructional materials	_____	_____	_____	_____

(Coding Sheet)

	Mentioned Only:	Unfavorable:	Favorable:	Intervention:
G. SCORES				
1. SAT/ACT	_____	_____	_____	_____
2. Other specialized tests	_____	_____	_____	_____
3. G.P.A.	_____	_____	_____	_____
4. Rank	_____	_____	_____	_____
H. CURRICULUM				
1. Adequate HS math and science subjects	_____	_____	_____	_____
2. Extracurricular SET programs	_____	_____	_____	_____
3. Math anxiety	_____	_____	_____	_____
4. Other specialized courses	_____	_____	_____	_____
5. Extracurricular non-SET activities	_____	_____	_____	_____
XVI. CAREER FACTORS				
A. COUNSELING				
B. EXPECTATIONS				
1. Job/career expectations	_____	_____	_____	_____
2. Advancement opportunity	_____	_____	_____	_____
C. ROLE MODELS				
1. Mentor	_____	_____	_____	_____
D. RETENTION				
1. Wages and salaries	_____	_____	_____	_____

(Coding Sheet)

	Mentioned Only:	Unfavorable:	Favorable:	Intervention:
2. Advancement opportunity	_____	_____	_____	_____
3. On-the-job peer support group	_____	_____	_____	_____
E. RECRUITMENT				
1. Networking for job contacts	_____	_____	_____	_____
F. WORK EXPERIENCE				
1. Military	_____	_____	_____	_____
2. Non-military	_____	_____	_____	_____

	Mentioned Only:	Yes:	No:	Intervention:
G. BARRIERS				
1. Sex bias	_____	_____	_____	_____
2. Race bias	_____	_____	_____	_____

XVII. PERSONAL FACTORS

	Mentioned Only:	Unfavorable:	Favorable:	Intervention:
A. ABILITY				
1. Skills for stress management	_____	_____	_____	_____
2. Aptitude	_____	_____	_____	_____
3. Hand/eye coordination	_____	_____	_____	_____
4. Male/female math and spatial differences	_____	_____	_____	_____

(Coding Sheet)

	Mentioned Only:	Unfavorable:	Favorable:	Intervention:
5. Adaptive capability (e.g., career recycling)	_____	_____	_____	_____
B. ATTITUDES				
1. Interest in SET	_____	_____	_____	_____
2. Attitude toward math/science	_____	_____	_____	_____
3. Recognition of SET objectives for career	_____	_____	_____	_____
4. Study habits	_____	_____	_____	_____
5. Motivated toward achievement	_____	_____	_____	_____
6. Self-concept, image, self-confidence, identity	_____	_____	_____	_____
C. EXPECTATIONS				
D. VALUES				
XVIII. ECONOMIC FACTORS				
A. FINANCIAL SUPPORT				
1. Grant	_____	_____	_____	_____
2. Scholarship	_____	_____	_____	_____
3. Internship	_____	_____	_____	_____
4. Work study	_____	_____	_____	_____

(Coding Sheet)

	Mentioned Only:	Yes:	No:	Inter-vention:
B. BARRIERS				
1. Financial support availability	_____	_____	_____	_____
2. Effect work on study time	_____	_____	_____	_____
3. Sex bias	_____	_____	_____	_____
4. Race bias	_____	_____	_____	_____

XIX. RESEARCH METHODS USED:

A. TYPE OF DATA USED: Cross-sectional_____ Longitudinal_____
Follow-up_____

B. MEASUREMENT (College):

1. Recruitment
2. Retention
3. Dropout
4. Stopout
5. Graduation
6. Grade Point Average
7. Quality of school life
8. Change of attitude
9. Transfers:
   a) From where
   b) To where
   c) 2 year to 2 year college
   d) 2 year to 4 year college
   e) 4 year to 4 year college
   f) 4 or more year to 4 or more year college
   g) 4 year to 2 year college

(Coding Sheet)

C. MEASUREMENT (For career path or industry):

1. Recruitment
2. Retention (staying at the same career)
3. Length of service at individual company
4. Job satisfaction
5. Other, please specify _____

D. MEASUREMENT
(Vocational/Technical)

1. Recruitment
2. Dropout
3. Graduation
4. Grade average
5. Quality of school life
6. Other, please specify

_____

E. MEASUREMENT
(High School)

1. Recruitment
2. Dropout
3. Graduation
4. Grade average
5. Quality of school life
6. Other, please specify

_____

(Coding Sheet)

NOTE: This page is for internal file manipulation. If the items listed below have been checked at any point while you coded this article, place an "X" in the space provided.

XX. _____ Counseling
XXI. _____ Expectations
XXII. _____ Role Model
XXIII. _____ Retention
XXIV. _____ Recruitment
XXV. _____ Barriers
XXVI. _____ Scores (SC)
XXV. _____ Curriculum (CC)
XXVI. _____ Work Experience (WX)
XXVII. _____ Ability (AB)
XXVIII. _____ Attitudes (AT)
XXIX. _____ Financial Support
XXX. _____ Values (VA)
XXXI. _____ Measurement*
XXXII. _____ Intervention
XXXIII. _____ Sex Bias
XXXIV. _____ Race Bias
XXXV. _____ Internship
XXXVI. _____ SAT
XXXVII. _____ GPA
XXXVIII. _____ Math Anxiety
XXXVIX. _____ Military
XL. _____ Self

*NOTE: An "X" here means at least one measurement was recorded on pages 10-11, number XIX.

_____ _____

Date Coder's Name

APPENDIX F
TEXAS SET EMPLOYMENT STATISTICS

TEXAS EMPLOYMENT FIGURES FOR TECHNOLOGY

Racial/Ethnic Group	Number	Percent
Both Genders	106,526	100.0
White	85,891	80.0
Hispanic	11,410	10.00
Black	6,719	6.0
Asian	2,122	1.0
American Indian	384	0.4
Males	84,173	79.0
White	68,498	80.0
Hispanic	9,483	84.0
Black	4,432	66.0
Asian	1,503	71.0
American Indian	257	67.0
Females	22,353	21.0
White	17,393	20.0
Hispanic	1,927	16.0
Black	2,287	34.0
Asian	619	29.0
American Indian	127	33.0

Source: U.S. Department of Labor, based on 1980 Census data

TEXAS EMPLOYMENT FIGURES FOR MATH

Racial/Ethnic Group	Number	Percent
Both Genders	1,978	100.0
White	1,719	86.0
Hispanic	120	6.0
Black	107	5.0
Asian	20	1.0
American Indian	12	0.6
Males	1,272	64.3
White	1,087	64.0
Hispanic	92	7.0
Black	75	71.0
Asian	13	65.0
American Indian	5	42.0
Females	706	35.7
White	632	36.0
Hispanic	28	23.0
Black	32	29.0
Asian	7	35.0
American Indian	7	58.0

Source: U.S. Department of Labor, based on 1980 Census data

TEXAS EMPLOYMENT FIGURES FOR PHYSICS/ENVIRONMENTAL SCIENCE

Racial/Ethnic Group	Number	Percent
Both Genders	19,913	100.0
White	17,944	90.0
Hispanic	728	3.0
Black	696	3.0
Asian	500	2.0
American Indian	45	0.2
Males	17,146	86.1
White	15,617	88.0
Hispanic	641	89.0
Black	463	67.0
Asian	398	80.0
American Indian	27	60.0
Females	2,767	13.9
White	2,327	12.0
Hispanic	87	11.0
Black	233	33.0
Asian	102	20.0
American Indian	18	40.0

Source: U.S. Department of Labor, based on 1980 Census data

TEXAS EMPLOYMENT FIGURES FOR ENGINEERING

Racial/Ethnic Group	Number	Percent
Both Genders	98,543	100.0
White	86,846	88.0
Hispanic	4,754	4.0
Black	2,500	2.0
Asian	4,181	4.0
American Indian	262	0.3
Males	94,115	95.5
White	83,251	96.0
Hispanic	4,513	95.0
Black	2,086	84.0
Asian	4,025	97.0
American Indian	250	96.0
Females	4,428	0.5
White	3,605	4.0
Hispanic	241	5.0
Black	414	16.0
Asian	156	3.0
American Indian	12	4.0

Source: U.S. Department of Labor, based on 1980 Census data

TEXAS EMPLOYMENT FIGURES FOR COMPUTER SCIENCE

Racial/Ethnic Group	Number	Percent
Both Genders	15,055	100.0
White	13,273	88.0
Hispanic	750	4.0
Black	592	3.0
Asian	366	2.0
American Indian	74	0.5
Males	11,932	79.3
White	10,644	81.0
Hispanic	619	83.0
Black	326	55.0
Asian	295	81.0
American Indian	48	65.0
Females	3,123	20.7
White	2,629	19.0
Hispanic	131	17.0
Black	266	44.0
Asian	71	19.0
American Indian	26	35.0

Source: U.S. Department of Labor, based on 1980 Census data

Both Genders